ADBI Working Paper Series

EFFECTIVENESS OF FOREIGN DEVELOPMENT ASSISTANCE IN MITIGATING NATURAL DISASTERS' IMPACT: CASE STUDY OF PACIFIC ISLAND COUNTRIES

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No. 1076
February 2020

Asian Development Bank Institute

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Suggested citation:

Chen, H. and B. Singh. 2020. Effectiveness of Foreign Development Assistance in Mitigating Natural Disasters' Impact: Case Study of Pacific Island Countries. ADBI Working Paper 1076. Tokyo: Asian Development Bank Institute. Available: https://www.adb.org/publications/effectiveness-foreign-development-assistance-mitigating-natural-disasters-impact

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Abstract

Natural disasters bring tremendous destruction to small island economies in the South Pacific region. Foreign development aid, as an important source of green finance in the region, has the fundamental purpose of reducing natural disasters' effect on the small island economies. With country level data on 13 Pacific island countries over 1981–2014, this study assesses the effectiveness of foreign development assistance in mitigating natural disasters' impact on Pacific economic growth. With the application of panel integration tests and the system generalized method of moments estimator, this study provides non-spurious and consistent empirical estimation of a growth model. It is found that while natural disasters greatly hinder economic growth in the region, official development assistance significantly mitigates such adverse effects.

Keywords: natural disaster, economic growth, South Pacific region, foreign development assistance

JEL Classification: Q54, O49, R10, F35

Contents

1. INTRODUCTION

Green finance plays an important role in Pacific island countries (PICs) in enhancing these small states' economic and social environments. With its purposes of improving infrastructure and reducing natural disasters' impacts, foreign development assistance is one of the major green funding sources in PICs. This study examines the effectiveness of foreign development assistance in reducing natural disasters' impact on economic growth in PICs. It is well noted that PICs are prone to natural disasters such as cyclones, floods, storm surges, tidal waves, and droughts. These extreme events cause cataclysmic damage and result in costly recovery and restoration of lost capital. A significant percentage of the population in PICs lives in rural areas and informal settlements; lacks basic economic, social, and financial infrastructure; and continues to depend on agriculture. These conditions make PICs particularly susceptible to natural disasters related to climate change.

On the other hand, PICs have benefited from billions of dollars of foreign development assistance over time. Most of this assistance is channeled into green infrastructure projects, such as building hydro projects, rural electrification, clean water projects, drainage and irrigation, building sea walls, and building better roads to provide better access to rural communities. Improving infrastructure directly mitigates and reduces the impacts of natural disasters on economic growth and development. Similarly, millions of dollars of foreign aid are provided to farmers to diversify economic opportunities and improve farming practices. Besides hard infrastructure, PICs also receive a substantial amount of foreign aid for soft infrastructure, such as building human capital and improving the empowerment of people. Investment in human capital not only enhances the socioeconomic status of communities and societies, and thus reduces their vulnerability to natural disaster, but also strengthens disaster preparedness and thereby reduces the overall economic and social cost of the natural disaster.

With country level data on 13 PICs over 1981–2014, this study assesses the effectiveness of green finance, namely foreign development assistance, in mitigating natural disasters' impact on Pacific economic growth. With the application of panel integration tests and the system generalized method of moments (GMM) estimator, this study provides a non-spurious and consistent empirical estimation of a growth model. It is found that while natural disaster greatly hinders economic growth in this region, official development assistance significantly mitigates such adverse effects. To our knowledge, this is the first study that examines the effectiveness of foreign development assistance in mitigating natural disasters' impact.

The remainder of the manuscript is organized as follows. Section 2 presents a brief literature review; section 3 provides a brief review of the data and model; section 4 presents econometric analyses and the discussion, and section 5 concludes.

2. LITERATURE REVIEW

The existing literature on natural disasters' impacts is inconclusive. One line of enquiry argues that natural disaster positively contributes to long-run economic growth through a process of creative destruction (Hallegatte and Dumas 2009; Skidmore and Toya 2002). Loss of physical capital induces firms to replace old production capital with more productive capital embedded in leading edge technology, which in turn benefits the economy (Aghion and Howitt 1992; Okuyama 2003; Okuyama, Hewings, and Sonis 2004). Similarly, households may construct improved houses with more efficient insulation and heating systems, which in turn may conserve energy and increase savings. Furthermore, reconstruction efforts by governments offer better infrastructure such as roads, utilities, hospitals, and schools, thereby improving the efficiency of the production process and accelerating human capital accumulation in the long term.

In contrast, a second strand of the literature highlights that climate calamity can permanently lower long-run economic growth (Hallegatte and Dumas 2009). According to this line of thought, loss of physical and human capital can put the economy on a lower growth path if positive spillover from pre-disaster physical and human capital is reasonably strong or when lost physical and human capital is not fully replaced in the aftermath of disaster (Romer 1990). Natural disasters not only destroy the existing stock of capital, but also lower the accumulation of capital through a drop in savings attributed to a rise in medical and emergency expenditure (Fankhauser and Tol 2005; Fankhauser, Tol, and Pearce 1997). Accumulation of assets is also hampered by increased depreciation, which is caused by massive damage and loss of infrastructure (Azariadis and Drazen 1990). In addition, developing countries generally lack financial resources, and it takes longer for governments to reallocate necessary resources to reconstruction efforts, which usually delays reconstruction investment (Hallegatte, Hourcade, and Dumas 2007). Moreover, reconstruction activities are often delayed due to a lack of the required skills.

Natural disasters may also cause social problems. It is argued that natural disasters may lead to a decline in effective labor force participation due to migration, increased disability rate, massive fatalities, poverty, and hunger. Poverty and hunger caused by natural disasters in turn lower household investment in education, as well as schooling achievement (Alderman, Hoddinott, and Kinsey 2006; Cuaresma 2010; Hamdan 2015; Lopez 2009). Public investment in education in the post-disaster period may also suffer as governments divert resources to reconstruction efforts (Lopez 2009). Furthermore, a massive transfer of foreign aid in the aftermath of a natural disaster may induce corruption and rent-seeking activities, which will in turn hamper long-term efficiency in the allocation of inputs (Brollo et al. 2013). Researchers such as Adger (1996, 1999); Daniel, Florax, and Rietveld (2009); Masozera, Bailey, and Kerchner (2007); and Schumacher and Strobl (2011) further argue that the relative impact of natural disaster is generally higher for low income countries, and that it may take them many years to fully recover from the aftermath of a natural disaster as they may not have resources to repair, reconstruct, and relocate.

However, while there is ample literature examining the impacts of natural disaster and foreign development assistance on economic growth, there is a lack of studies examining the effectiveness of foreign development assistance in mitigating the effects of natural disaster.

3. MODEL AND DATA

The empirical model to examine the effectiveness of foreign development assistance in mitigating natural disasters' impact on economic growth in PICs is centered on the discussion in the literature and the availability of data for PICs. The growth model takes the following panel data structure:

$$gy_{it} = \alpha_0 + \sum_{j}^{J} \gamma_j disaster_{j,it} + \sum_{k=1}^{K} \beta_k X_{k,it} + \pi_i + \sigma_t + \varepsilon_{it} \qquad (1)$$

where gy_{it} is annual growth rate of GDP per capita at constant 2005 prices (%), $disaster_{it}$ is a vector of core variables measuring the severity of natural disasters, X_{it} is a vector of control variables, π_i denotes time-invariant country-specific effects, σ_t denotes country-invariant time-specific effects, and ε_{it} is the error term.

Explanatory variables and their potential impact on economic growth in PICs are as follows.

Natural disaster dummy variables (denoted by $disaster_{j,it}$)

The ratio of the population affected in natural disasters is used to gauge the magnitude of natural disasters for a nation. Data on natural disasters and population affected are obtained from EM-DAT from the Centre for Research on the Epidemiology of Disasters (CRED).

To avoid non-normal distribution of natural disaster magnitude due to a large number of zero values in the natural disaster magnitude series, this series is converted into dummy variables. $Disaster_{1,it}$ has a value of 1 for years where the ratio is between 10% and 20%, and 0 otherwise. The second dummy variable $disaster_{2,it}$ has a value of 1 for years where the ratio is more than 20%, and 0 otherwise. These dummy variables are time and country variant, and they are expected to have negative effects on economic growth in the South Pacific.

Investment rate (denoted by $invr_{it}$)

Investment rate is represented by gross fixed capital formation as a percentage of GDP. This indicator is used to measure increments in physical capital input. According to economic growth theories, it is expected to have a positive impact on long-run output growth.

Population growth (denoted by n_{it})

There is no consistent conclusion on population growth's impact on economic growth. Normally, the rate of return on investment in human capital and the accumulation of knowledge is likely to increase with growth in the population. Therefore, if a rise in returns to human capital due to a higher population is greater than the effects of a higher population on diminishing growth, population growth will positively contribute to growth in GDP per capita (Becker, Glaesser, and Murphy 1999; Kremer 1993).

Manufacturing-to-total value added ratio (denoted by $manur_{it}$)

The manufacturing industry adds value to primary products; to a great extent it also captures the degree of industrialization in developing countries. Therefore the development of the manufacturing industry contributes positively to output growth.

Exports-to-GDP ratio (denoted by $exportsr_{it}$)

Exports positively contribute to output growth through the channel of enhancing production efficiency; this is because exports increase demand for domestic products, which promotes economies of scale.

Imports-to-GDP ratio (denoted by $importsr_{it}$)

Imports' growth impact is ambiguous. Imports promote output growth, given the technology spillover effects; however, such positive effects are weakened if a significant proportion of imports are substitutes for domestic products.

Government final consumption expenditure-to-GDP ratio (denoted by $govconsr_{it}$)

Government final consumption expenditure in the developing South Pacific region is expected to contribute positively to economic growth, which can be seen from the three following aspects. (i) A noticeable proportion of government final consumption expenditure includes social transfers and governments' spending on education, health, infrastructure, and other public projects. This is positively associated with production efficiency and human capital. (ii) PICs are frequently affected by natural disasters which result in economic loss, loss of lives, and social disruption. Government final consumption expenditure to some extent offsets the adverse effects brought about by natural disasters. (iii) In some PICs where the total population is very small, government consumption spending as percentage of GDP is generally high. In the Marshall Islands, Federated States of Micronesia, and Tuvalu, the ratio is higher than 50%. In these countries, due to the noteworthy composition of civil services in the whole economy, a significant proportion of government final consumption expenditure is individual consumption expenditure; this, together with household final consumption expenditure, spurs economic growth.

Total official development flows-to-GDP ratio (denoted by $odfr_{it}$)

Most PICs receive a significant amount of official development flow (ODF) relative to their GDP. The major part of ODF is used to improve infrastructure development, education, health, and natural disaster resilience in recipient countries, or to help recipient countries to recover quickly from damage caused by disasters. Therefore ODF is expected to be positively associated with economic growth in the developing South Pacific region.

Moreover, statistics show an increase in ODF received by PICs following natural disasters. It is also observed that there is a positive association, with a correlation coefficient of 0.24, between the severity of natural disasters and the ODF-to-GDP ratio. Given this, the interaction between $disaster_{j,it}$ and odf_{it} is considered in the Pacific speed of growth model.

Table 1: Sources of Data

Data Source	Series Required	Variable in the Model
National Accounts Main Aggregates Database	GDP (constant 2005, US$)	gy_{it}
	Total population (persons)	
	Gross fixed capital formation (constant 2005, US$)	$invr_{it}$
	Manufacturing value added (constant 2005, US$)	$manur_{it}$
	Exports of goods and services (constant 2005, US$)	$exportsr_{it}$
	Imports of goods and services (constant 2005, US$)	$importsr_{it}$
	Government final consumption expenditure (constant 2005, US$)	$govconsr_{it}$
	GDP (current, US$)	
OECD StatExtract	Total official development flows (current US$)	$odfr_{it}$
EM-DAT from the Centre for Research	Total affected population in natural disasters (persons)	$disaster_{j,it}$

on the Epidemiology of Disasters (CRED)	

The above model is estimated based on a sample of 13 PICs over 1981–2014. These countries include the Cook Islands, Fiji, Kiribati, the Marshall Islands, the Federated States of Micronesia, Nauru, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu. Niue is not included in the current study due to severe lack of data; French Polynesia and New Caledonia are not included due to their French territory status and inconsistent availability of data on official development flows. Furthermore, data on official development flows are not available before 1992. Data sources are presented in Table 1. Table 2 summarizes data on the total affected population in natural disasters, and summary statistics of main economic and social indicators are presented in Table 3.

Table 2: Total Population Affected by Natural Disasters by Year (persons)

Country	Year	Total Affected	Country	Year	Total Affected	Country	Year	Total Affected
Cook Is.	1987	2,000	Micronesia	2004	6,008	Solomon Is.	1991	24
Cook Is.	1990	1,200	Palau	1996	12,004	Solomon Is.	1992	
Cook Is.	1997	1,023	PNG	1980	40,000	Solomon Is.	1993	88,500
Cook Is.	2001	744	PNG	1983	38,000	Solomon Is.	1997	
Cook Is.	2005	608	PNG	1986	1,000	Solomon Is.	1998	380
Cook Is.	2009	1,247	PNG	1987	4,000	Solomon Is.	2002	1,110
Cook Is.	2010	2,202	PNG	1988	1,000	Solomon Is.	2003	425
Fiji	1981	4,700	PNG	1991	5,000	Solomon Is.	2007	2,384
Fiji	1983	242,146	PNG	1992	90,000	Solomon Is.	2009	7,000
Fiji	1985	122,000	PNG	1993	114,240	Solomon Is.	2010	17,733
Fiji	1986	218,000	PNG	1994	152,062	Solomon Is.	2012	4,836
Fiji	1987	3,369	PNG	1996	1,837	Solomon Is.	2013	15,526
Fiji	1990	6,000	PNG	1997	515,500	Solomon Is.	2014	52,000
Fiji	1992	2,000	PNG	1998	9,867	Tonga	1982	146,514
Fiji	1993	160,003	PNG	1999	38,000	Tonga	1990	3,103
Fiji	1997	3,500	PNG	2000	5,000	Tonga	1997	3,000
Fiji	1998	263,455	PNG	2001	1,596	Tonga	1998	3,571
Fiji	1999	1,772	PNG	2002	20,859	Tonga	2001	16,500
Fiji	2003	30,000	PNG	2003	621	Tonga	2009	561
Fiji	2004	5,600	PNG	2004	19,600	Tonga	2014	4,014
Fiji	2006	392	PNG	2005	17,693	Tuvalu	1990	700
Fiji	2007	969	PNG	2006	25,999	Tuvalu	1993	150

Fiji	2009	14,401	PNG	2007	162,140	Vanuatu	1985	117,500
Fiji	2010	39,101	PNG	2008	75,300	Vanuatu	1987	48,000
Fiji	2012	27,945	PNG	2009	7,391	Vanuatu	1988	9,700
Kiribati	1999	84,000	PNG	2011	4	Vanuatu	1990	2
Kiribati	2008	85	PNG	2012	200,000	Vanuatu	1992	1,160
Kiribati	2014	220	PNG	2013	35,000	Vanuatu	1993	12,005
Marshall Is.	1991	6,000	PNG	2014	40,726	Vanuatu	1998	2,400
Marshall Is.	2000	218	Samoa	1983	2,000	Vanuatu	1999	14,100
Marshall Is.	2008	600	Samoa	1990	195,000	Vanuatu	2001	5,300
Marshall Is.	2013	6,384	Samoa	1991	88,000	Vanuatu	2002	4,004
Marshall Is.	2014	360	Samoa	2009	5,584	Vanuatu	2004	54,008
Micronesia	1987	203	Samoa	2012	12,703	Vanuatu	2005	5,000
Micronesia	1998	28,800	Solomon Is.	1982	30,000	Vanuatu	2008	9,000
Micronesia	2000	3,431	Solomon Is.	1985	650	Vanuatu	2009	1,350
Micronesia	2002	1,623	Solomon Is.	1986	150,000	Vanuatu	2011	32,000
Micronesia	2003	1,000	Solomon Is.	1988	500	Vanuatu	2014	20,006

Note: Cook Is. = Cook Islands; Marshall Is. = Marshall Islands; Micronesia = Federated States of Micronesia; PNG = Papua New Guinea; Solomon Is. = Solomon Islands.

Source: The Emergency Events Database (EM-DAT) by the Centre for Research on the Epidemiology of Disasters (CRED).

Table 3: Key indicators of 13 independent PICs

Country	**Year/Period**	**Per Capita GDP (2005 Constant Prices, US$)**	**Growth of Real per Capita GDP** (%)	**Population** (persons)	**Growth of Population** (%)	**Investment-to-GDP Ratio** (%)
Cook Islands	1981–1990	5,577	4.19	17,596	–0.01	18.84
	1991–2000	7,914	2.69	18,018	0.12	14
	2001–2010	9,433	–0.13	19,344	1.29	13.48
	2011–2014	9,091	1	27,426	1	17
Fiji	1981–1990	2,590	1.34	703,215	1.37	17.67
	1991–2000	3,100	0.99	777,259	1.08	15.18
	2001–2010	3,562	0.64	830,998	0.59	16.47
	2011–2014	3,813	0.92	871,332	0.82	15.76
Kiribati	1981–1990	1,247	–0.82	63,277	2.65	48.08
	1991–2000	1,206	1.62	77,232	1.53	36.34
	2001–2010	1,205	–1.08	91,104	1.66	44.17
	2011–2014	1,115	0.21	100,018	1.53	45.37
Marshall Islands	1981–1990	2,117	1.84	39,455	4.36	62.85
	1991–2000	2,319	–0.12	50,877	0.98	57.37
	2001–2010	2,619	2.62	52,184	0.05	56.79
	2011–2014	3,004	1.75	52,525	0.12	56.79
Federated States of Micronesia	1981–1990	1,903	1.22	86,354	2.78	31.75
	1991–2000	2,173	1.05	105,808	1.09	31.73
	2001–2010	2,332	0.55	105,663	–0.36	31.05

	2011–2014	2,380	1.02	103,410	–0.11	30.5
Nauru	1981–1990	16,566	–0.5	8,312	2.01	48.08
	1991–2000	6,044	1.01	9,868	0.92	36.34
	2001–2010	3,093	–0.74	10,076	–0.02	44.27
	2011–2014	6,251	–1.96	10,028	0.03	42.69
Palau	1981–1990	7,691	1.69	13,769	2.13	10.53
	1991–2000	8,547	–0.51	17,416	2.4	18.75
	2001–2010	8,877	–0.19	19,956	0.65	35.39
	2011–2014	8,489	2.92	20,680	0.69	25.75
Papua New Guinea	1981–1990	719	–1.26	3,726,367	2.57	14.93
	1991–2000	858	1.92	4,795,934	2.58	12.41
	2001–2010	831	1.52	6,178,503	2.43	17.94
	2011–2014	1,105	6.83	7,089,994	2.2	30.29
Samoa	1981–1990	1,525	–0.6	159,943	0.46	27.1
	1991–2000	1,632	2.25	170,061	0.7	18.45
	2001–2010	2,334	2.27	180,605	0.63	10.71
	2011–2014	2,453	0.63	188,159	0.76	9
Solomon Islands	1981–1990	944	–0.26	274,890	3.02	20.52
	1991–2000	1,076	–0.96	365,218	2.79	10.4
	2001–2010	935	2.39	474,972	2.44	12.91
	2011–2014	1,193	2.26	543,798	2.15	14.77
Tonga	1981–1990	12,122	3.98	94,205	0.23	20.26
	1991–2000	2,204	2.03	96,317	0.29	19.32
	2001–2010	2,544	0.76	101,307	0.61	23.48
	2011–2014	2,643	1.34	104,748	0.4	31.58
Tuvalu	1981–1990	1,115	4.98	8,645	1.12	73.71
	1991–2000	1,881	3.98	9,241	0.45	59.31
	2001–2010	2,430	0.23	9,685	0.42	59.34
	2011–2014	2,653	3.98	9,852	0.17	49.41
Vanuatu	1981–1990	1,734	1.2	131,940	2.38	19.31
	1991–2000	1,963	1.2	168,956	2.33	20.85
	2001–2010	1,970	0.45	212,288	2.44	28.45
	2011–2014	2,103	–0.79	244,520	2.27	29.34

continued on next page

Table 3 *continued*

Country	Year/Period	Exports- to-GDP Ratio (%)	Imports- to-GDP Ratio (%)	Manufacturing-to-GDP Ratio (%)	Government Final Consumption Expenditure-to-GDP Ratio (%)	Official Development Flows-to-GDP Ratio (%)[a]
Cook Islands	1981–1990	76.3	101.12	4.83	48.1	35.76
	1991–2000	62.16	59.19	3.33	39.63	12.55
	2001–2010	75.02	62.25	3.92	31.57	6.16
	2011–2014	104	76	4	37	7
Fiji	1981–1990	51.68	45.93	11.89	17.17	3.99
	1991–2000	55.05	58.48	12.39	16.72	2.08
	2001–2010	51.27	63.27	12.82	16.38	2.13
	2011–2014	58.6	63.3	12.28	14.55	3.04
Kiribati	1981–1990	17.99	121.13	3.61	42.98	44.36
	1991–2000	15.29	68.47	4.77	32.4	30.86
	2001–2010	14.41	100.59	4.54	39.38	21.12
	2011–2014	11.4	102.67	4.5	40.45	36.65
Marshall Islands	1981–1990	17.49	123.26	1.45	50.99	
	1991–2000	12.32	114.97	2	54.04	40.39
	2001–2010	12.44	114.46	2.09	54.12	43.67
	2011–2014	12.44	114.45	1.84	54.12	42.33

Federated States of Micronesia	1981–1990	18.07	79.08	1.44	52.16	
	1991–2000	17.93	78.84	1.5	52.12	34.78
	2001–2010	19.83	77.32	0.95	51.02	44.02
	2011–2014	26.41	81.09	0.39	50.11	39.93
Nauru	1981–1990	17.99	121.13	1.89	42.98	0.15
	1991–2000	15.29	68.47	1.88	32.4	12.21
	2001–2010	14.7	101.34	2.68	39.47	59.98
	2011–2014	12.6	92.58	3.1	38.07	36.97
Palau	1981–1990	17.65	52.75	2.37	38.16	
	1991–2000	13.23	61.17	2.97	37.18	58.04
	2001–2010	57.65	74.72	2.05	33.63	15.57
	2011-2014	65.26	68.18	1.59	34.26	11.54
Papua New Guinea	1981–1990	49.62	54.19	8.01	21.29	12.48
	1991–2000	57.85	38.46	6.75	15.51	8.07
	2001–2010	66.65	55.3	6.04	16.51	6.62
	2011–2014	42.01	85.76	6.37	17.75	9.86
Samoa	1981–1990	27.45	62.42	16.76	19.65	26.99
	1991–2000	29.47	62.03	15.75	25.78	24.67
	2001–2010	30.46	55.16	14.38	22.24	12.81
	2011–2014	31.26	53.19	9	19.76	16.25
Solomon Islands	1981–1990	51.01	79.69	5.77	36.28	23.26
	1991–2000	26.26	60.75	6.53	48.43	15.06
	2001–2010	31.31	48.46	8.05	35.53	33.42
	2011–2014	49.08	47.7	10.03	23.51	35.3
Tonga	1981–1990	26.44	87.15	11.12	14.46	18.43
	1991–2000	22.07	70.94	8.36	16.8	13.77
	2001–2010	16.68	58.86	7.09	16.43	11.67
	2011–2014	15.38	58.33	6.39	15.28	19.06
Tuvalu	1981–1990	6.51	73.9	2.15	63.3	150.89
	1991–2000	2.93	62.45	1.26	75.33	58.07
	2001–2010	1.61	64.38	0.91	76.29	53.97
	2011–2014	1.7	50.78	1.03	77.05	80.31
Vanuatu	1981–1990	39.54	64.64	3.69	37.47	22.11
	1991–2000	37.98	50.41	4.66	25.68	16.14
	2001–2010	42.77	54.73	3.88	13.75	12.62
	2011–2014	53.77	59.96	4.23	13.37	12.55

Note: [a] Data on official development flows to Marshall Islands, Federated States of Micronesia, and Palau are not available before the year 1992.

4. METHODOLOGY AND FINDINGS

Three issues pertaining to panel data analysis are addressed here: (1) empirical evidence is non-spurious, as all variables integrated are of order zero; (2) instrumental variables are used to address endogeneity issues; and (3) empirical findings are generally consistent across regressions using different samples. Empirical evidence is presented along with details of the methodologies used.

4.1 Integration test

The Breitung panel integration test, testing the null hypothesis that panels contain unit roots, is used to test the integration order of all quantitative variables in the model. In each Breitung test, time trend is not included and cross-sectional means are subtracted. Panel integration tests for the other quantitative variables are based on 13 countries' data. All 34 years (1981–2014) are included in all integration tests.

The Breitung integration test results are summarized in Table 4. Since all *p*-values are less than 0.05, the null hypothesis of non-stationary panels is rejected in each panel integration test at the 5% significance level. A combination of these quantitative variables would therefore yield non-spurious regression results.

Table 4: Breitung Panel Integration Test Results

Variable	# countries	# Lag	Lambda	*p*-value
gy_{it}	13	1	–3.15	0.0008
$invr_{it}$	13	1	–3.20	0.0007
n_{it}	13	1	–4.33	0.0000
$manur_{it}$	13	0	–3.84	0.0001
$exportsr_{it}$	13	1	–2.92	0.0017
$importsr_{it}$	13	1	–2.83	0.0023
$govconsr_{it}$	13	1	–3.29	0.0005
$odfr_{it}$	13	1	–3.76	0.0001

Note: $odfr_{it}$ uses 1992–2014 data based on availability; all other variables' integration tests use 1981–2014 data.

4.2 The GMM Estimation of the Growth Model

A concern in the growth literature is the endogeneity of some regressors. In the current model, identifying determinants of growth and their respective contributions, some regressors are likely affected by other factors in the model. For instance, investment ratio is likely to be influenced by economic growth and manufacturing value added ratio; education attainment and health are likely to be affected by economic growth, government final consumption expenditure, and official development flows; official development flows ratio is likely to be explained by economic growth, education attainment, health, and occurrence of natural disasters. Failure to address the endogeneity problem will produce biased empirical results. We use instrumental variables estimation to address the issue. In the current study, the system GMM estimator, with autocorrelation and heteroskedasticity consistent robust standard errors, is employed to estimate the panel regression model as shown in Equation (1). This estimator reports test statistics from the Arellano-Bond (A-B) test for autocorrelation and the Sargan test of overidentification restrictions. The former test has the null hypothesis of no autocorrelation; the latter has the null hypothesis that parameters are overidentified. The system GMM estimation results are summarized in Table 5.

Table 5: The system GMM Estimation of Pacific Speed of Growth, gy_{it}

Independent Variable	(1)	(2)	(3)	(4)	(5)
$disaster_{1,it}$	–4.251***	–9.28***	–3.416	–6.873***	–6.123***
	(–2.70)	(–6.49)	(–1.04)	(–6.22)	(–2.63)
$disaster_{2,it}$	–1.964*	–4.252**	–1.798	–1.638	–1.077
	(–1.55)	(–2.17)	(–0.86)	(–0.88)	(–0.25)
$invr_{it}$	0.0548**	0.0293*	0.0624**	0.0664*	0.0616
	(1.84)	(1.63)	(2.07)	(1.31)	(0.95)
n_{it}	0.00191	–0.323	–0.106	0.352*	0.361
	(0.01)	(–0.79)	(–0.19)	(1.56)	(1.05)
$manur_{it}$	0.471***	0.568***	0.504***	0.647***	0.666***
	(2.98)	(4.37)	(3.01)	(6.49)	(5.99)
$exportsr_{it}$	0.0482*	0.07**	0.034	0.0972***	0.106**
	(1.53)	(1.8)	(0.74)	(3.43)	(1.78)

importsr$_{it}$	–0.0393***	–0.034	–0.0720***	–0.0741***	–0.0746***
	(–2.95)	(–1.23)	(–5.58)	(–4.55)	(–2.37)
govconsr$_{it}$	0.122***	0.065**	0.0977***	0.311***	0.338***
	(2.75)	(2.21)	(2.37)	(5.82)	(3.91)
odfr$_{it}$		0.819**			
		(1.87)			
disaster$_{1,it}$**odfr*$_{it}$		28.8***			
		(5.89)			
disaster$_{2,it}$**odfr*$_{it}$		20.59**			
		(2.64)			
Constant	–6.256**	–7.195*	–3.315	–14.16***	–15.43**
	(–1.74)	(–2.22)	(–1.03)	(–4.56)	(–2.78)
Period	1981–2014	1992–2014	1981–2014	1981–2014	1981–2014
# countries	13	13	8	9	6
# observations	442	299	272	306	204
Wald χ^2 [*p*-value]	65.36[0.000]	721.02[0.000]	109.63[0.000]	1,184.87[0.000]	1,324.33[0.000]
A-B test for AR(2) *p*-value	0.303	0.552	0.537	0.290	0.427
Sargan test *p*-value	0.540	0.445	0.414	0.662	0.448
Hansen test p-value	0.672	0.835	0.768	0.894	0.687

Notes:

(1) z statistics are in parentheses; p-values are in square brackets.

(2) *, **, and *** respectively represent that the corresponding variable is statistically significant at the 10%, 5%, and 1% significance levels. These are obtained based on one-tailed hypothesis tests given the hypotheses described in the model. $Z_{\alpha=0.10}$ = 1.28, $Z_{\alpha=0.05}$ = 1.64, and $Z_{\alpha=0.01}$ = 2.33.

(3) There is no multicollinearity problem in the above regressions. Coefficients of pairwise correlation among independent variables are all within the range -0.65 to 0.65.

Since *p*-values from the Arellano-Bond tests for the second-order autocorrelation AR(2) are all greater than 0.05, autocorrelation within countries is not evidenced at the 5% significance level. Similarly, since all *p*-values from the Sargan tests of overidentification are all greater than 0.05, overidentification of parameters in individual regressions is evidenced at the 5% significance level. These tests suggest the system GMM estimates are consistent and efficient.

4.3 Robustness of Estimates

This study investigates the effectiveness of foreign development assistance in mitigating natural disasters' impact on GDP in 13 PICs over a period of three decades (1981–2014). Findings on growth empirics from cross-country studies are to some extent sensitive to choice of sample. Homogeneity of sample countries plays an important role in producing robust estimates. In the current study, a robustness check is conducted by using different sets of PICs, time periods, and regressors.

To check the robustness of estimates and utilize data that are available for the current study, regression (1) includes all 13 PICs over the whole period 1981–2014; regression (2) includes 13 PICs over 1992–2014, the period for which ODF data are available for all PICs under investigation; regression (3) excludes the Cook Islands, Fiji, Kiribati, the Marshall Islands, and the Federated States of Micronesia; regression (4) excludes Solomon Islands, Tonga, Tuvalu, and Vanuatu; and regression (5) includes the Marshall Islands, the Federated States of Micronesia, Nauru, Palau, Papua New Guinea, and Samoa.

4.4 Interpretation of Empirical Findings

A glance at the regression output across five columns in Table 5 suggests that estimates are consistent with the assumptions presented in Section 3.

Natural disasters prove devastating to small Pacific island economies. Based on the findings of regression (2), which incorporates official development assistance in the Pacific speed of growth model, it is found that the occurrence of a natural disaster affecting between 10% and 20% of the total population on average reduces the rate of real GDP per capita growth by 9.28 percentage points in this region, *ceteris paribus*. The occurrence of a natural disaster affecting more than 20% of the total population, however, has a less significant damaging impact on economic growth, both statistically and quantitatively: on average, it reduces the rate of real GDP per capita growth by 4.25 percentage points in this region, *ceteris paribus*.

Meanwhile, it is observed that interactive effect of official development assistance and natural disaster indicators has a large and positive impact on economic growth. Assuming that a natural disaster is exogenous, official development assistance increases with the natural disaster's devastating effects. Hence, the positive and significant signs of the interaction terms $disaster_{1,it}*odfr_{it}$ and $disaster_{2,it}*odfr_{it}$ suggest that the adverse growth impacts of natural disasters are greatly mitigated by green finance—that is, by official development assistance.

Looking at the control variables, it is found that a 10 percentage point increase in investment-to-GDP ratio is associated with a 0.29 percentage point increase in growth of real GDP per capita, all else being equal. The gap between the maximum and minimum investment ratios among the 13 PICs over 1981–2014 was 64.71%; this contributed to a difference of 1.88 (= 0.029*64.71) percentage points in the expected growth of real GDP per capita among the developing South Pacific region.

Manufacturing proves an important determinant in the Pacific speed of growth model. It is evidenced that a rise of 10 percentage points in the manufacturing value added-to-total value added ratio leads to a 5.7 percentage point rise in the growth of real GDP per capita, keeping other variables unchanged. Such a positive effect is highly significant at the 1% significance level. The gap between the maximum and minimum share of manufacturing sector in GDP in the 13 PICs over 1981–2014 was 13.78%; this contributed to a difference of 7.85 (= 0.57*13.78) percentage points in the expected growth of real GDP per capita among the developing South Pacific region.

The exports-to-GDP ratio has a coefficient of 0.07, suggesting that a 10 percentage point increase in the exports ratio increases growth of real GDP per capita by 0.7 percentage points, *ceteris paribus*. Such an effect is highly significant at the 1% significance level. The gap between the highest and lowest export-to-GDP ratios among the 13 PICs over 1981–2014 was 76.51%; this contributed to a difference of 5.36 (= 0.07*76.51) percentage points in the expected growth of real GDP per capita among the developing South Pacific region.

Imports turn out to be harmful to small Pacific island economies, suggesting that their negative crowding out effect outweighs their positive technological spillover effect on growth. Regression analysis shows that a 10 percentage point increase in the imports-to-GDP ratio reduces economic growth by around 0.3 percentage points, *ceteris paribus*. The gap between the highest and lowest import-to-GDP ratios among the 13 PICs over 1981–2014 was 84.8%; this contributed to a difference of 2.26 (= 0.029*84.80) percentage points in the expected growth of real GDP per capita among the developing South Pacific region.

Government final consumption expenditure proves helpful in promoting economic growth in this region. It is found that a rise of 10 percentage points in the government final consumption expenditure-to-GDP ratio increases economic growth by 0.65 percentage points, all else fixed The gap between the highest and lowest government final consumption expenditure-to-GDP ratios among the 13 PICs over 1981–2014 was 63.68%; this contributed to a difference of 4.14 (= 0.065*63.68) percentage points in the expected growth of real GDP per capita among the developing South Pacific region.

Official development flows is the last quantitative series considered in the current study. It turns out to be highly significant, with positive growth impact. An increase of 10 percentage points in the official development flows-to-GDP ratio is associated with an increase of 8.19 percentage points in economic growth, *ceteris paribus*. The lowest ODF ratio was seen in Nauru over 1981–1990, while the highest ratio was seen in Tuvalu over 1981–1991. The gap between the highest and lowest official development flows-to-GDP ratios among the 13 PICs over 1981–2014 was 150.89%; this contributed to a difference of 124 (= 0.819*150.89) percentage points in the expected growth of real GDP per capita among the developing South Pacific region.

It is worth noting that the estimated intercept is –7.20, suggesting that, on average, the growth rate of real GDP per capita in the South Pacific region is negative, given that mean values of explanatory variables are all zero. This magnitude may incorporate negative growth effects of omitted factors, such as budget deficit, as in Gani (1998) and Jayaraman and Lau (2009); initial GDP per capita and debt, as in Tumbarello, Cabezon, and Wu (2013); and geographic disadvantage of PICs and growth volatility, as suggested by Yang et al. (2016). However, these assumptions need to be tested if data allow or if different growth models such as growth-initial income models are used.

5. CONCLUSION

This study sought to analyze the effectiveness of foreign development assistance, as a source of green finance, in mitigating natural disasters' impact on economic growth in the developing South Pacific region. The ratio of the population affected by a natural disaster was used to measure its severity. The impacts of natural disasters on economic growth were then assessed in panel regression analyses. Applying the Breitung panel integration test and the system GMM estimator, this study provides non-spurious and consistent analytical results. It is found that natural disasters significantly slow down economic growth in this region.

Natural disasters have emerged as a key determinant of growth in PICs. Moreover, it is observed that while official development assistance directly contributes positively to economic growth, it also effectively mitigates the negative impact of natural disasters on economic growth. This finding suggests that foreign development assistance is not only effective in promoting economic growth in the Pacific region, but it also limits the impact of natural disasters on the economy.

This finding has some important policy implications. Firstly, policy measures should ensure efficient and timely assistance to the region. Secondly, a significant amount of foreign aid before and in the aftermath of a natural disaster should be targeted toward better building, and productive investment should include improved technology and should be more resistant to shocks. International cooperation with international meteorology institutions should be explored to facilitate more accurate weather forecasting and improve the broadcast system to deliver weather messages more effectively. Moreover, foreign development assistance should be channeled into educating communities and building better and more sustainable health facilities, which are essential to minimize the human and economic cost of natural disasters.

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