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Why Sovereign Wealth Funds for Disaster Resilience in the Pacific?

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Why Sovereign Wealth Funds for Disaster Resilience in the Pacific?

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Abstract

This paper examines the important role that can be played by sovereign wealth funds (SWFs) in financing of disaster risk management. Governments of Tuvalu and Kiribati are predicting future climate and disaster risks to impose increasing financial pressure. Having the required financial response in the aftermath of disasters, such as cyclones, is of crucial importance to these low-lying atoll nations. We examine and forecast the long-term sustainability and feasibility of SWFs to contribute into ex-post disaster risk management by employing an Auto-Regressive Integrated Moving Average (ARIMA) model using SWFs data and calculated likely costs for disasters by the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) as our appropriate levels of financial support for expected disasters in Tuvalu and Kiribati.

JEL Codes: C53, E17, Q01, Q54, Q56

Keywords: Disaster risk, sovereign wealth funds, Pacific Islands, climate funds, resilience.

1. Introduction

Small Island Developing States (SIDS) are very vulnerable and exposed to climatic disasters. Many studies point out the unique vulnerability and exposure of Pacific Islands to climatic risks due to their economic, geographical, and environmental characteristics (see World Bank, 2014; Taupo, Cuffe, & Noy, 2016; OECD & World Bank, 2016), causing massive financial losses to their economies (Briguglio, 1995; Heger, Julca, & Paddison, 2008; Klomp & Valckx, 2014). Even cyclones that do not make landfall have economic impacts on these small islands, particularly Tuvalu (see Taupo & Noy). An additional existential threat of climate change and sea level rise to these small and low-lying atoll states in the Pacific like Tuvalu and Kiribati, will require long-term solutions associated with potential options of protecting the atoll islands or moving the populations to safer grounds (OECD & World Bank, 2016).

Recently, response efforts for Tuvalu after the 2015 Tropical Cyclone Pam (TC Pam) were led by the Government through the Disaster Committee, with support from humanitarian and bilateral partners. Based on situational assessments of the impact of the disaster, the government, and regional and international organizations responded to key areas of humanitarian need. There was neither disaster fund, nor any liquid financial instrument in place at that time to assist in this endeavour, apart from the Government's redirection of other expenditure lines.

Here, we propose to estimate the feasibility of a funding mechanism for disaster relief based on a Sovereign Wealth Fund (SWF) model. For that purpose, we: (1) Quantify the need for such a funding mechanism; (2) suggest a way to structure this mechanism through the SWFs of Tuvalu and Kiribati; and (3) examine the long-term sustainability of this proposed funding arrangement. We may ask why there is a need for a new disaster funding mechanism that supplements current official disaster assistance from development and donor partners. Autonomy, self-sufficiency, and predictability in relation to disaster response and recovery inspire this study. Because of this, we examine the two SWFs of Tuvalu and Kiribati. The separation of Tuvalu from Kiribati, along with their independence from Britain, led to the establishment of the Tuvalu Trust Fund (TTF) while Kiribati's Revenue Equalizer Reserve Fund (RERF) had already been established.[1]

As far as we are aware, no forecasts have been produced for the success of the TTF or RERF in the long run, nor any analysis of their feasibility and sustainability in providing financing mechanisms for disaster preparation and response. The possibility of extending TTF coverage to disasters apart from the provision of government support has been proposed but remains unquantified[2], hence the aim of this study to assess the feasibility and sustainability of these funds to support and contribute to disaster funds. Additionally, the paper intends to enhance understanding of potential options available for DRR and disaster response for

[1] Tuvalu and Kiribati are categorized as Least Developed Countries (LDC) by United Nations (UN) classification.
[2] This was raised in several meetings in Tuvalu, including the TC Pam Meeting, National Summit for Tuvalu for the new National Sustainable Development Strategy for 2015-2020 and the 2015 Tuvalu TTF Board Meeting (also mentioned in their 2015 TTFAC Report).

Tuvalu and Kiribati. Current findings can then be generalised to other Pacific or SIDS settings.

The next section describes the background of available disaster financing instruments. Section 3 discuss the SWF, section 4 describes the data and explains the methodology, section 5 details the results, and conclusions are presented in section 6.

2. Climate Change and Disaster Financing Instruments

There are numerous financing instruments available for climate change and climatic disasters. Linnerooth-Bayer and Mechler (2009) discuss insurance and risk-financing mechanisms for managing disasters in developing countries.[3] One of these earliest instruments is the Caribbean Catastrophe Risk Insurance Facility (CCRIF), which is a pool of catastrophe insurance covering of small island states in the Caribbean region, with a 'parametric trigger' for immediate insurance disbursements to affected states in the event of a disaster for emergency relief.[4] To encourage and enforce disaster risk management and adaptation to climate change in PICs, the Pacific Catastrophe Assessment and Financing Initiative (PCRAFI) was devised to model disaster risks and assess financial options, aiming at reducing financial vulnerability to disasters and climate change. Interestingly, the intended formation of the Pacific Islands Climate Change Insurance Facility (PICCIF) has become a popular topic in discourse

[3] Some examples of risk financing instruments are the Proshika scheme which offers the Participatory Livestock Compensation Fund (PLCF), the Afat Vimo disaster insurance program, the United States National Flood Insurance Program (NFIP), the Turkish Catastrophe Insurance Pool (TCIP), the Philippines crop insurance program, the BASIX index-based crop insurance scheme, the Mongolian index-based livestock insurance (IBLI) program, the Mexican catastrophe bond, the Caribbean Catastrophe Risk Insurance Facility (CCRIF), and the Mauritius crop insurance program.

[4] The Caribbean Catastrophe Risk Insurance Facility (CCRIF) was set up in 2007.

within the Pacific region.[5] In reality, insurance is not a practical instrument for disaster response and recovery for some Pacific Islands like Tuvalu given its very small size (see Taupo & Noy, 2016).[6] Kiribati has an operating Insurance Corporation but it does not cover the sovereign and insurance penetration is comparatively low.[7]

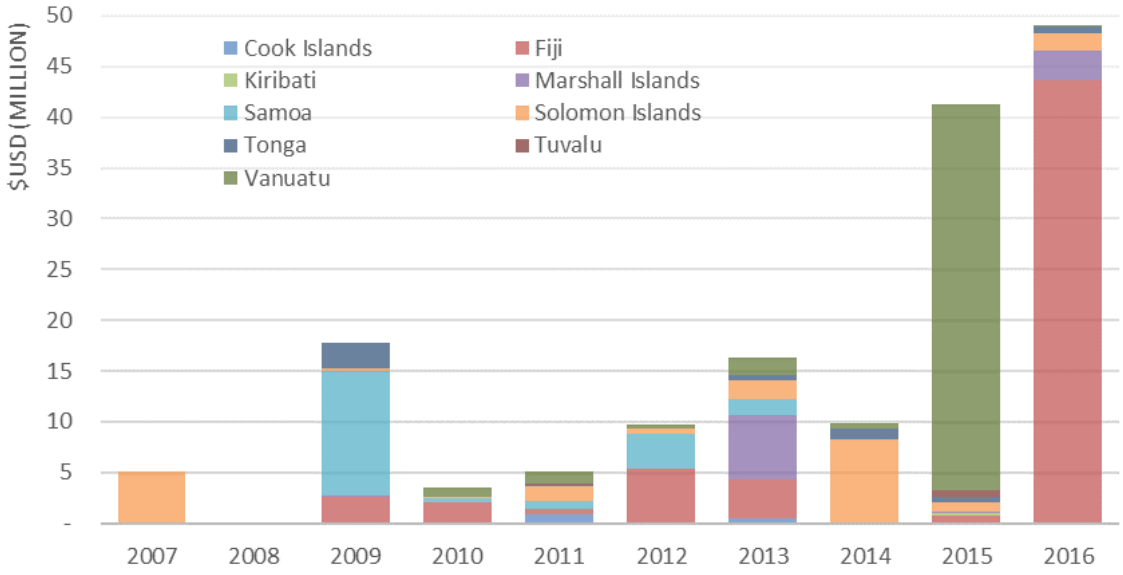

Figure 1: Humanitarian Aid Flows for Disasters in Selected PICs. Data are from the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA) website (https://fts.unocha.org/countries/overview).

Figure 1 shows how some PICs are receiving post disaster assistance from foreign donors and development partners. We focus on a group of low-lying atoll nations, members of the Coalition of Low-Lying Atoll Nations on Climate Change

[5] The Prime Minister of Tuvalu, in his statement at the High-Level Meeting of the Conference of the Parties (COP22) on the 16th of November 2016, stressed that the Pacific region is progressing towards the development of a Pacific Island Climate Change Insurance Facility (PICCIF) to help in recovery efforts, with the help of the UNDP and the Pacific Island Forum Secretariat. He also called upon all donors and experts to help in this endeavour. See statement at http://www.tuvalu-overview.tv/eng/topics/statement-cop22.html. Another disaster insurance for some PICs is the Pacific Catastrophe Risk Insurance Company.

[6] Apart from the unavailability of insurance mechanisms and insufficient resources (low income), "charity hazard" is a concern possibility deterring donors and the national government recipients (see Raschky & Weckhannemann, 2007).

[7] The Kiribati Insurance Corporation was established in 1981 to compensate loss and damages under two main categories: Life insurance and General (Non-Life) insurance, including vehicles, motor cycles, marine and aviation, fire, liability, and miscellaneous. Refer to http://www.kic.org.ki/index.php/about-us.html.

(CANCC) that was organised at the UN SIDS Conference in Samoa in September 2014. This group consists of the five low-lying atoll states: Kiribati, Tuvalu, the Maldives, Republic of Marshall Islands, and Tokelau, all of which are at the frontline of climate change and sea level rise. Figure 2 illustrates humanitarian aid flow for disasters from donors to the CANCC in the past 10 years, amounting to approximately USD$12 million.[8] The Marshall Islands dominated humanitarian aid for CANCC within this period, due to the two droughts they experienced in 2013 and 2016.

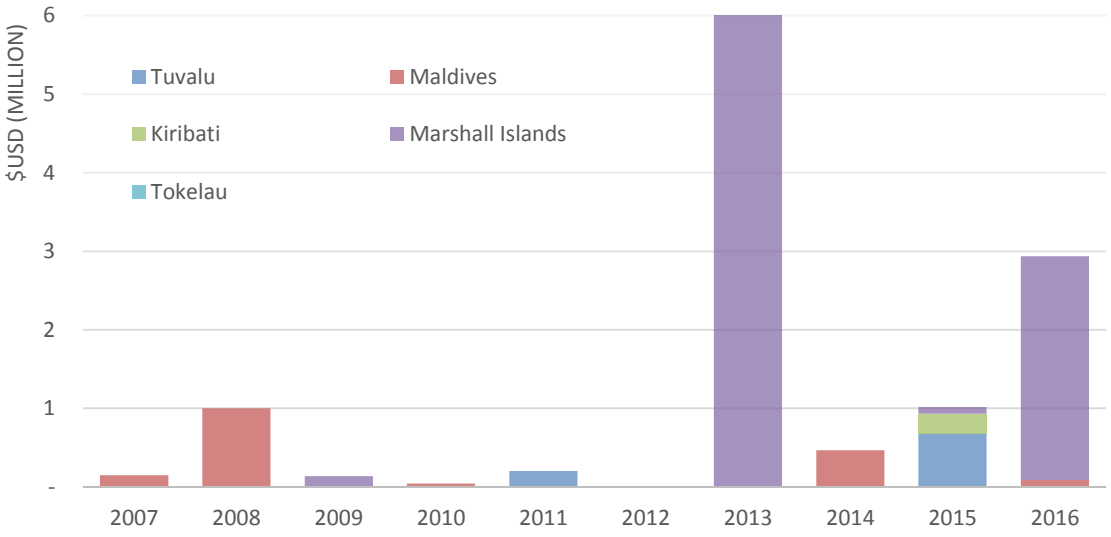

Figure 2: Humanitarian Aid Flows for Disasters in Low-Lying Atoll Islands. Data are from the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA) website (https://fts.unocha.org/countries/overview).

Tuvalu received USD$681,284 for TC Pam in 2015. The Tuvalu Government (2015) approximated a total of AUD$3.5 million from cash, in-kind, and pledge donations for relief and recovery efforts. Figure 3 displays spikes of net Official

[8] We use Australian Dollar currency (AUD) throughout this paper, unless otherwise stated. AUD is the currency used by both Tuvalu and Kiribati.

Development Assistance (ODA) for Tuvalu, corresponding to two state emergencies (in yellow bars): the 2011 drought and TC Pam in 2015. The year of the establishment of the Tuvalu Trust Fund is represented by the highest spike, in 1987 (green bar). Similarly, Figure 4 shows ODA and GDP for Kiribati. Kiribati was also affected by the 2011 drought and TC Pam in 2015, but not to the extent like Tuvalu where a state of emergency was declared for both events.

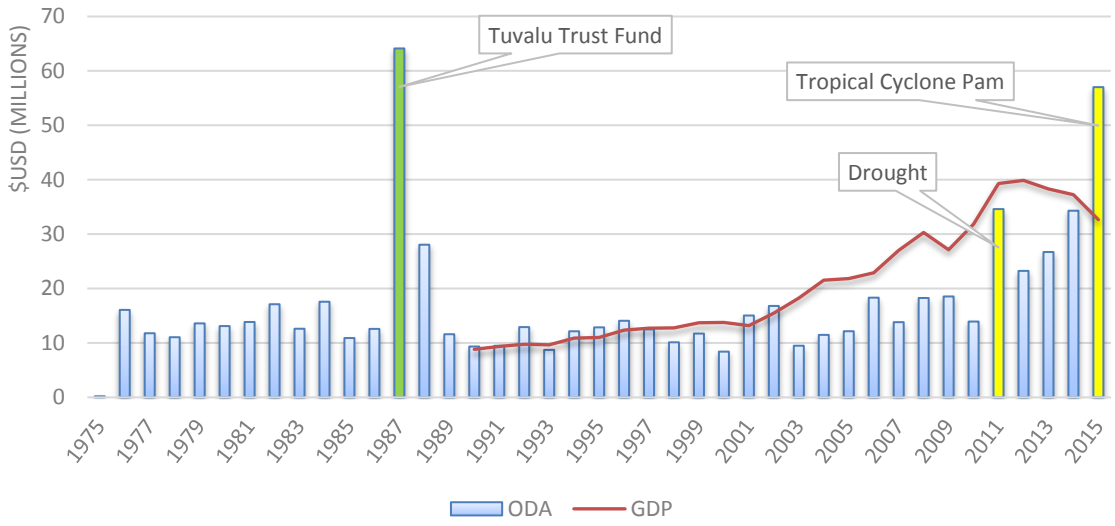

Figure 3: ODA and GDP for Tuvalu. Data are from the World Bank Databank website (http://databank.worldbank.org/data/).

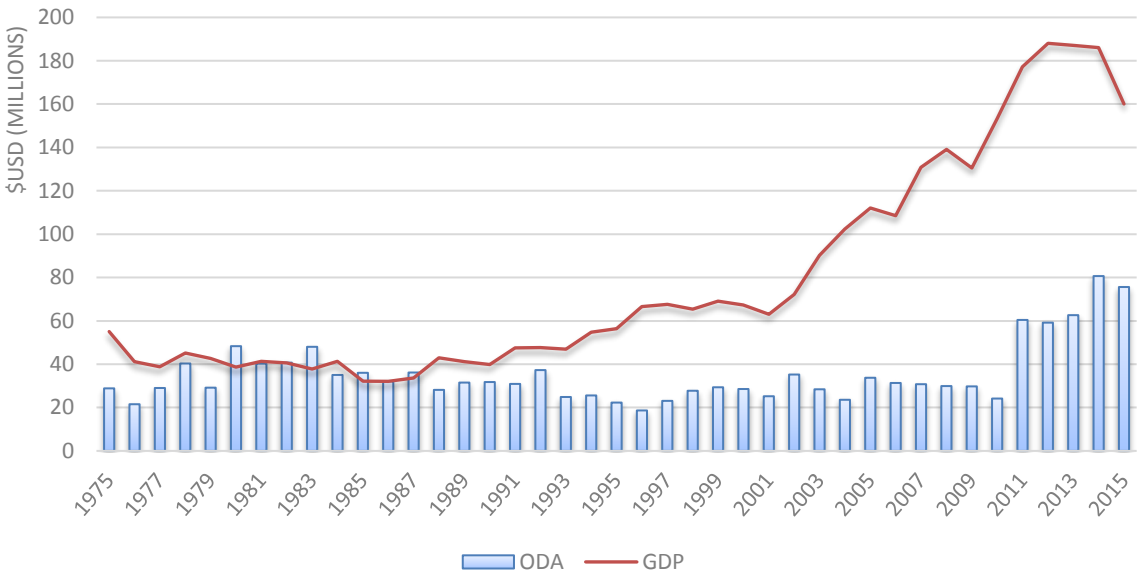

Figure 4: ODA and GDP for Kiribati. Data are from the World Bank Databank website (http://databank.worldbank.org/data/).

PICs have received funding from other sources for climate change adaptation, mitigation, and resilience purposes. One of these sources are projects from the National Adaptation Programmes of Action (NAPA), which have provided limited funding assistance to some PICs like Tuvalu, Kiribati, Samoa, the Solomon Islands, and Vanuatu to enable effective responses and adaptation to the effects of climate change.[9] Moreover, the Green Climate Fund (GCF) has approved a handful of projects for some PICs with the aim to assist vulnerable countries in building climate resilience, climate adaptation, and mitigation.[10]

[9] The preparation and implementation of NAPAs are financed by the Least Developed Countries Fund (LDCF). This fund supports the special needs of Least Developed Countries (LDCs) who are vulnerable to the adverse impacts of climate change (see Global Environment Facility Secretariat (2011)). Information on all NAPA Priority Projects are available on the United Nations Framework Convention on Climate Change (UNFCCC) website (http://unfccc.int/adaptation/workstreams/national_adaptation_programmes_of_action/items/4583.php).

[10] Refer to the Green Climate Fund (GCF) website on http://www.greenclimate.fund/projects/portfolio.

Noy and Edmonds (2016) discuss risks in Pacific atoll islands and various financial instruments applicable to both ex-ante and ex-post disaster risk management: i) post-disaster budget provisions; ii) offshore funds; iii) contingent credit lines and multilateral loans and grants; iv) insurance for public assets; v) private insurance; vi) sovereign insurance, and vii) regional pooling of sovereign insurance.

3. Sovereign Wealth Funds

Alhashel (2015) discusses the recent popularity of SWFs, as they have amassed up to USD6.65 trillion in 2014.[11] Balding (2012) and Clark et al. (2013) focus on the management, politics, and economics behind them. However, there is very limited research on SWFs in the PICs.[12] Several PICs, including Kiribati, Tuvalu, Timor-Leste, Papua New Guinea, Nauru, Tonga, the Marshall Islands, Micronesia, and Palau have SWFs established from revenue sources ranging from non-renewable resources, revenue windfalls, and donor contributions. These funds have served their governments for short-term budget stabilization, long-term savings, and the improvement of self-reliance (see Le Borgne & Medas, 2007).

In general, structures (legal, institutional, and governance) and investment strategies vary between these SWFs.[13] These SWFs cover economic disturbances and

[11] The estimate was gathered from the Sovereign Wealth Fund Institute at http://www.swfinstitute.org/fund-rankings/ . Similarly, when accessing http://www.swfinstitute.org/sovereign-wealth-fund-rankings/ on the 15th November 2016, the total SWFs added up to USD7.3957 trillion, which is represented by Total oil and gas related (USD4.3213 trillion) and Total others (USD3.0744 trillion). In comparison, the USD0.7457 trillion increase from 2014 to 2016 is 11.21%.

[12] Limited quantitative research on SWFs in Pacific Island Countries partly due to strict access to data.

[13] For instance, Tuvalu's TTF operation and fiscal policy requires achieving certain sustainability benchmarks such as having balanced budgets on average over the medium term; budget deficits should be below 3 percent of GDP; assets in the CIF should be above 16 percent of the TTF's assets over any four-year period; drawdown

long-term liabilities rather than natural shocks. Given the current circumstances of climate change and climatic disasters on Pacific Islands, the focus would need to be directed into the setting up of disaster funds if there are none, or contributing to existing disaster budget allocations.[14]

A globally accepted best practice for SWFs, such as the 'Santiago Principles' can weigh how SWFs are performing in terms of good governance, accountability, transparency, and prudent investment practices.[15] The 'Santiago Principles' consist of twenty-four Generally Accepted Principles and Practises (GAPP) that are supported by members of the International Working Group of Sovereign Wealth Funds (IWG)[16] as guidelines for proper, prudent and sound management of SWF. The International Working Group of Sovereign Wealth Funds (2008) broadly arranged the twenty-four GAPP into three pillars, namely: i) legal framework, objectives, and coordination with macroeconomic policies; ii) institutional framework and governance structure, and iii) investment and risk management framework.[17]

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from the CIF that is compatible with the sustainability of TTF; and external debt should be below 60 percent of GDP (TTFAC Secretariat, 2003, 2006).

[14] Beyond this endeavour is the aim to sustain disaster funds into the long-term.

[15] The Principles were established in 2008 with inputs from the IMF, World Bank, OECD, and others.

[16] IWG consist of 26 IMF member countries with SWFs. The International Working Group of Sovereign Wealth Funds (2008) discusses the "Santiago Principles" in detail. The International Forum of Sovereign Wealth Funds (IFSWF) was an off spring of the 'Kuwait Declaration' in 2009, as the successor of the IWGSWF. IFSWF currently has 30 member countries.

[17] Furthermore, the International Forum of Sovereign Wealth Funds (2014) prescribed the 'Santiago Principles' as follows: 1) sound legal framework; 2) well defined policy purpose and public disclosure of framework; 3) compliance with macroeconomic policies; 4) clearly defined policies and rules; 5) timely reporting and transparency to the owner(s); 6) clearly defined division of roles; 7) clear objectives and roles for governing bodies; 8) governing bodies to act in the best interest of the SWF; 9) independence and following procedures; 10) clear accountability framework; 11) timely annual reporting; 12) independent auditors; 13) upholding internal ethical standards; 14) clear outsourcing procedures; 15) compliance with rules of foreign countries; 16) clear governance framework; 17) public transparency; 18) clear investment policies and strategies; 19) investment decisions based on economic and financial grounds; 20) privileged information restrictions; 21)

Table 1: Compliance with the Santiago Principles by Fund for selected PICs

	Countries (in descending order of compliance)			
	Timor-Leste (TLPF)	Tuvalu (TTF)	FSM & RMI (CTFs)	Kiribati (RERF)
2011 SWF Scoreboard*	73			
2013 SWF Scoreboard*	85			35
2014 Compliance Index Rating**	A			
2015 Rating***				
1. Legal Framework	Good	Good	Good	Good
2. Objectives and policy purpose	Good	Good	Good	Neutral
3. Domestic economic implications	Good	Good	Neutral	Good
4. Investment policy and risk management	Good	-	-	Poor
5. Governance framework	Good	Good	Good	Neutral
6. Professional and ethical standards, fiduciary and public responsibility	Neutral	Poor	Poor	Poor
7. Transparency	Good	Neutral	Neutral	Poor

Source: * denotes scores (with a 100-point scale) calculated by Bagnall and Truman (2011, 2013), ** Santiago compliance index rating computed by GeoEconomica (2014), while *** refers to the rating classifications (Good, Neutral, Poor) determined by Edmonds (2015). "-" refers to insufficient information.

The Timor-Leste Petroleum Fund (TLPF) is the only SWF from the Pacific that is a member of the IWG. Not only has it performed well against the "Santiago Principles", it has also improved over the years (see table 1). In contrast, the RERF has not performed well in 2013 relative to the other forty-eight SWFs assessed, with 19 points below the SWF average score (Bagnall & Truman, 2013). On the other hand, the TTF has not been thoroughly assessed in comparison to other SWF at the international level, but only at the Pacific regional level by Edmonds (2015), where he divided the twenty-four GAPP into seven[18] thematic areas and ranked the SWF for selected PICs including Timor-Leste, Tuvalu, Kiribati, the Federated States of Micronesia (FSM), and the Republic of the Marshall Islands (RMI). Table 1 shows

shareholder ownership rights policies; 22) reliable and effective risk management; 23) clear and proper reporting of performance, and 24) regular review of compliance with the 'Santiago Principles'.

[18] The 7 categorized areas are shown in Table 1.

that Tuvalu's TTF was performing well overall in 2015, while underperforming in the categorised area 6. Likewise, Kiribati's RERF was performing poorly in categorized areas 4, 6, and 7. The identified weaknesses should be key focus areas for improvement. Tuvalu on the other hand, requires a thorough assessment of its compliance to the 'Santiago Principles' in the future. However, with the inclusion of TTF contributions to the disaster fund, it will most likely deviate from the 'Santiago Principles'.[19]

3.1 Tuvalu Trust Fund and the Revenue Equalizer Reserve Fund

The TTF is guided by its International Agreement for the Tuvalu Trust Fund with advice and monitoring from the TTFAC and Fund managers. According to the Tuvalu Government (2008, p. 6) "the purpose of the Fund is to contribute to the long-term financial viability of Tuvalu by providing an additional source of revenue for recurrent expenses of the Government of Tuvalu in order to: (a) assist the Government to achieve greater financial autonomy in the management of its recurrent budget; (b) enable the Government to maintain and if possible improve existing levels of social infrastructure and services; (c) enhance the capacity of the Government to receive and effectively utilize external capital development and technical assistance; (d) enable the Government to meet long-term maintenance and operating costs of social and economic infrastructure and services; and (e) assist the Government to develop the economy of Tuvalu".

[19] Also, it does not state in the TTF Agreement.

The RERF is a special fund under Section 107 of the Constitution where the Minister of Finance can directly wind up the Fund under section 13(2)(b) of the Public Finance (Control and Audit) Act.[20] Although we have not sighted[21] the objectives, mission, and policy purposes of the RERF, both the TTF and RERF, in general support their governments fiscally, providing reliable revenue sources (fiscal buffers) to offset recurrent national budget shortfalls and occasionally smoothing out relevant market fluctuations[22] when necessary.

The TTF was formed in 1987 from initial investments from both donors and the national government, while the RERF was established purely from the national government's contributions (Ministry of Finance & Economic Development, 2016; Toatu, 1993; Trease, 1993; TTFAC Secretariat, 2006, 2015; Tuvalu Trust Fund Board, 2007).

[20] The Constitution and the Public Finance (Control and Audit) Act were both accessed on March 21st, 2017 through http://www.paclii.org/ki/constitution/Kiribati%20Independence%20Order%201979.pdf and http://www.paclii.org/ki/legis/consol_act/pfaaa279/. See Angelo et al. (2016) for more discussion on the overview of the SWF in the Pacific and how they are distinguished from one another.

[21] We assume that the information for RERF is either not publicly available or does not exist at all. However, in principle, the usage of RERF is reflected in their national budgets.

[22] The TTFAC Secretariat (2015, p. 11) identified potential "sources of fiscal risk from uncertainty include volatility in: 1) foreign exchange rates (notably USD/AUD), which affect several major USD-denominated revenue items (e.g. licence fees for fishing and '.tv, and the ROC budget support payments); 2) volume of traded items (e.g. fish harvested under a licence agreement); 3) market prices of traded items (e.g. VDS fishing days); 4) timing of cash flows (e.g. sales of various fishing licences); 5) capital markets (e.g. affecting investment returns); 6) demand driven, loosely constrained expenditure policies; and the incidence of random natural disasters affecting Tuvalu (e.g. Cyclone Pam)."

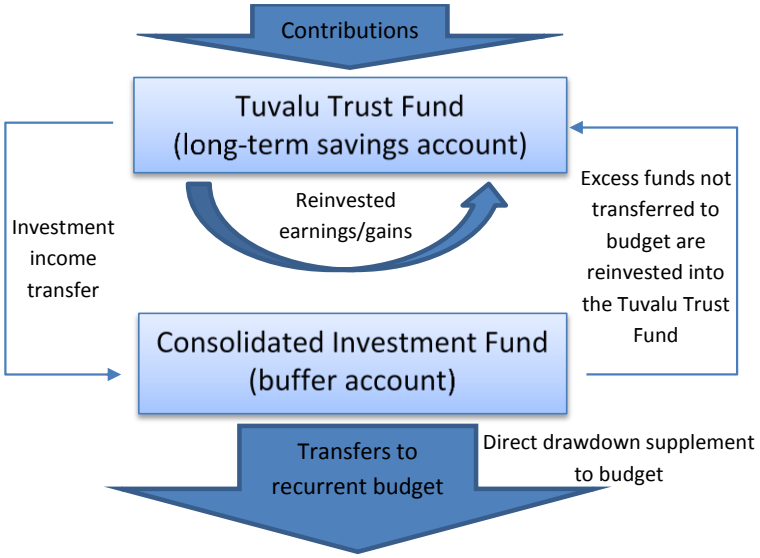

Figure 5: Tuvalu Trust Fund Resource Flow.

Figure 5 describes the current TTF structure that consists of contributions from the original donors and subsequent contributors including the Tuvalu government. Positive distributions or investment income are transferred to the Consolidated Investment Fund (CIF) for disbursement. The CIF acts as a buffer in the current structure.[23] Any excess of funds in the CIF that are not transferred to the government budget are either stored in the CIF or reinvested back into the TTF. Figure 6 shows a potential alternative structure for the SWF, proposing to connect the TTF to a disaster fund. In this proposal, the TTF will provide support to the disaster fund in terms of contributions.

[23] Other Pacific Islands without SWFs and buffer accounts meet national budget deficits by borrowing at high interest rates.

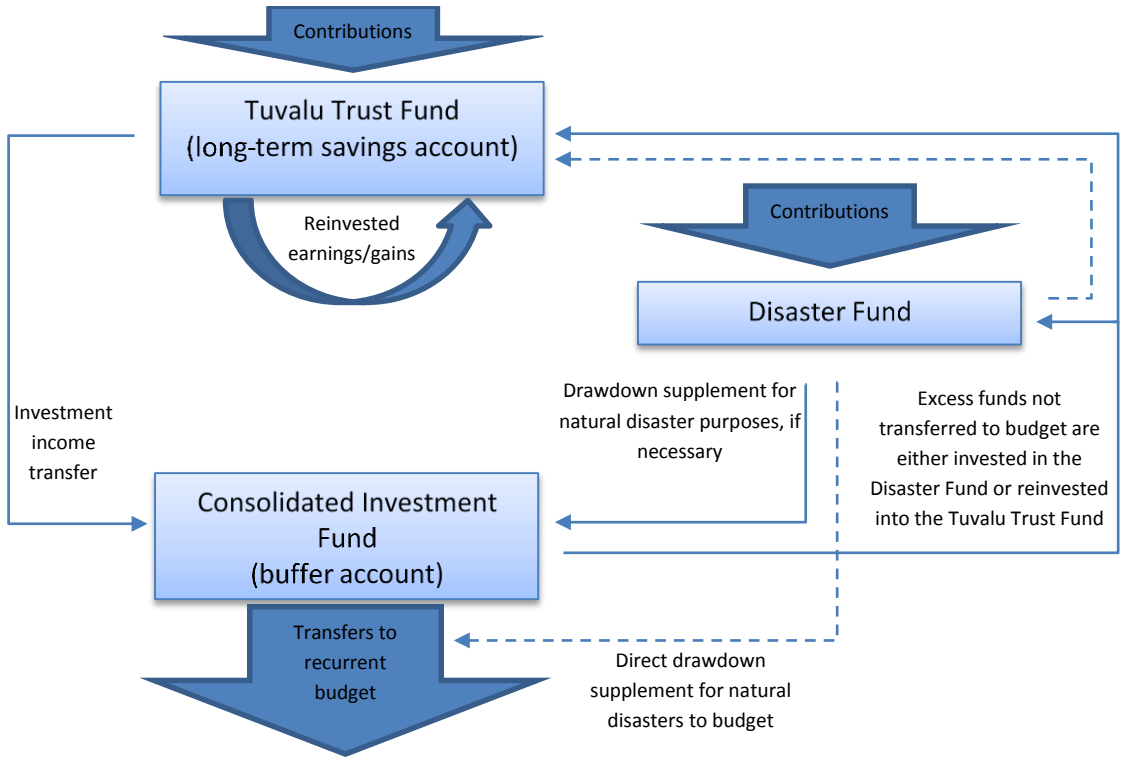

Figure 6: Alternative Tuvalu Trust Fund Resource Flow.

One of the priority goals set out in the 2015 National Summit on Sustainable Development (NSSD) for Tuvalu is to protect the nation from the impacts of climate change through better resilience, mitigation, and adaptation. Parallel to this goal is the commitment of the government to establish in its national budget the 'Tuvalu Survival Fund', to financially support the building of resilience in communities, disaster response, and climate proofing infrastructure (Ministry of Finance & Economic Development, 2016).[24] Kiribati has a disaster fund in place.

In relation to managing the performance of these funds, global market uncertainties and volatilities remains an issue. However, Tuvalu and Kiribati are mindful that strong fiscal performance can be attributed to projected fiscal surpluses,

[24] At the wake of TC Pam, the political will to establish a disaster fund known as the 'Tuvalu Survival Fund' surfaced.

increase in revenues from grants and fishing licenses, and increasing contributions into their funds. Apart from other revenue sources, both countries earn from tuna catches, through fisheries agreements for foreign vessels to fish in their sea territories.

4. Data and Method

We employed the Auto-Regressive Integrated Moving Average (ARIMA) model to forecast the future of the TTF and RERF. The ARIMA model enabled us to project future values and/or trends from our time series data. We used time series data on both the TTF and RERF. Data are yearly from financial years 1987 to 2016 and 1984 to 2016 for Tuvalu and Kiribati, respectively. Data on the TTF were gathered from the TTF Secretariat of the Tuvalu Government, while the RERF annual values were acquired from the Kiribati's Ministry of Finance and Economic Development.[25] Annual reports on the Funds and the national budgets were also used to complement these data.[26]

The ARIMA model used was proposed by Box and Jenkins (1970), which is an extension of the Auto-Regressive Moving Average (ARMA) model.[27] The ARMA is the combination of Auto-Regressive (AR) and Moving Average (MA) models (thus it combines both p autoregressive terms and q moving average terms), both of which model lagged values of y_t and ε_t past errors as predictors (see e.g., Diebold, 2006). The first component in the ARMA model is the AR model, where the value in a

[25] Data for RERF were gathered from both the Ministry of Finance & Economic Development and their official website (http://www.mfed.gov.ki/).
[26] Other Pacific Islands with SWFs were also approached for their data, but declined.
[27] ARIMA is sometimes referred to as the integrated ARMA model. See Diebold (2006) for detail discussions on AR, MA, and ARMA models.

period is related to its values in previous periods. Hence, $AR(p)$ is an autoregressive model with p lags where $y_t = \mu + \varepsilon_t + \sum_{i=1}^{p} \gamma_i y_{t-i}$. The second component is the MA model, which accounts for the relationship between a variable in a period and the residuals in previous periods. Therefore, $MA(q)$ is a model of moving average with q lags, where $y_t = \mu + \varepsilon_t + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i}$. Hence, we arrive on the ARIMA model where d is the required degree of differencing to make the series stationary (the number of times the data have had past values subtracted), for instance, a first order difference in y_t is the differenced variable $\Delta y_t = y_t - y_{t-1}$ (Box & Jenkins, 1970; 1976; Hyndman & Athanasopoulos, 2014). Therefore, an $ARIMA(p, d, q)$ represents a model with p autoregressive lags, q moving average lags, and a difference in the order of d as given in Equation 1:

$$y_i^d = \mu + \sum_{i=1}^{p} \gamma_i y_{t-i}^d + \varepsilon_t + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i} \qquad \text{Equation 1.}$$

Here, values of our dependent variable y, measured in time, t, that is represented by y_t are affected by the values of y in the past (or lags), μ is a constant, γ_p is the coefficient for the lagged variable in time $t - p$, ε_t is the error term at time t, and θ_q is the coefficient for the lagged error term in time $t - q$.

The stationarity condition is a requirement in modelling an $ARMA(p, q)$ process, where the mean and variance does not change over time and the process does not have trends. When this condition is unmet, then non-stationarity is evident in the data and we cannot use ARMA. However, we can resort to the Box-Jenkins procedures (see Box & Jenkins, 1976) by using an ARIMA model (see equation 1),

which is the reason we chose ARIMA instead of ARMA.[28] We follow the Box-Jenkins method for ARIMA model selection in our diagnostics, where we use the Dickey-Fuller tests for stationarity[29], Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) for correlations, and Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) measures for goodness of fit of the model (see Box & Jenkins, 1976; Makridakis, Wheelwright, & Hyndman, 1997).

5. Results and Discussions

We used the risk estimates supplied by the Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) for Tuvalu and Kiribati to determine the required contributions into disaster funds before discussing the forecast results from the two models under discussion. The computed Average Annual Loss (AAL) from PCRAFI estimates that annual economic losses averaged over the 10,000 realisations of next-year activity. These computed values were used as our appropriate levels of financial support (or contributions) from SWFs into disaster funds for expected disasters in Tuvalu and Kiribati.[30]

[28] The Box-Jenkins procedures follows the four steps: 1) preliminary transformation; 2) identification; 3) estimation of the model, and 4) diagnostic checking. Makridakis et al. (1997) further discusses the use of Box-Jenkins methods for ARIMA models, while Nasiru & Olanrewaju (2015) employed these methods.

[29] This procedure requires the differencing of the time series until it is stationary, this will ensure the removal of any trend or seasonal components.

[30] Hallegatte (2013) discusses the basic measure that assesses the exposure of assets during a catastrophe, called the Exceedance Probability (EP) curve, where the area below the constructed EP curve is the AAL, which is the expected amount of loss on average per year for a certain location. The PCRAFI calculates losses from earthquakes and tropical cyclones.

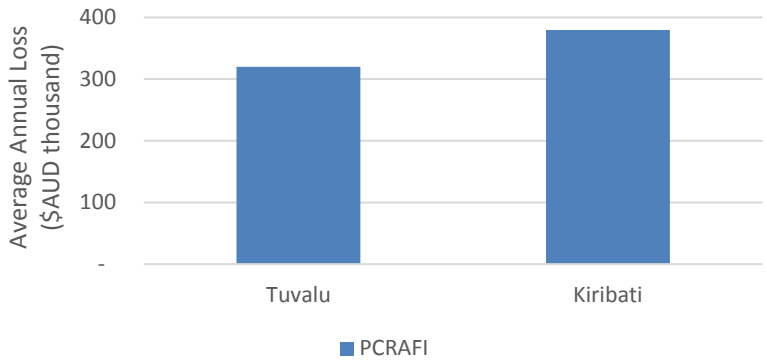

Figure 7: Annual Average Loss (AAL) Adjustments for Tuvalu and Kiribati. Author's conversions of calculated PCRAFI's AALs to AUD$ (Australian currency).

Figure 7 illustrates the adjusted AALs for Tuvalu and Kiribati based on PCRAFI's calculations. Under these conditions, the TTF and RERF would have amassed overall estimated contributions to their disaster funds at the end of the financial year 2026 in the order of $3.2 million and $3.8 million, respectively.[31] An alternative condition is where contributions to the disaster fund are derived from the adjusted AAL as a percentage to SWF, which may vary over time depending on SWF size. Under this alternative scenario, the TTF and RERF would amassed overall estimated contributions to their disaster funds at the end of the financial year 2026 in the order of $15.6 million and $26.2 million, respectively. In the following section, we will present the forecasting results for the two SWFs together with scenarios including estimated contributions to their disaster funds using the forecasting approach discussed below.

To formally test for stationarity for both TTF and RERF data, we used the Dickey Fuller test, with which the results showed that the original variables are not

[31] These figures are direct contributions from the TTF to the disaster fund in 2016 prices, excluding other contributions from other potential sources.

stationary, but that the differences variables are stationary (see table A1)[32]. Therefore, we resorted to the ARIMA model (as oppose to the ARMA model) where we used differences $d = 1$. Based on our selection criteria (see table A2 and table A3), we chose our parsimonious models of ARIMA (1,1,1)[33] and ARIMA (1,1,3) to forecast the TTF and RERF, respectively, since they both have significant coefficients and lowest AIC and BIC that indicate goodness of fit of the models. The regression equations for ARIMA(1,1,1) and ARIMA(1,1,3) for the TTF and RERF, respectively, are shown below:

$$y_i^1 = 4{,}558{,}357.1 + 0.89y_{t-1}^1 + \varepsilon_t - \varepsilon_{t-1} \qquad \text{Equation 2 (TTF)}$$

$$y_i^1 = 20{,}553{,}135.9 + 0.677y_{t-1}^1 + \varepsilon_t - 0.632\varepsilon_{t-1} + 0.328\varepsilon_{t-2} - 0.696\varepsilon_{t-3} \qquad \text{Equation 3 (RERF)}$$

Using the ARIMA model with 30 and 33 observations for the TTF and RERF respectively, we were able to generate forecasts for 10 periods (commencing from 2017 to 2026) out into the future with 90% confidence limits for both funds (see figure 8 and figure 9).[34] As expected, the forecast bands widen as we move further into the forecast horizon. These forecasts show how SWFs are likely to perform with or without the inclusion of contributions to disaster funds.

[32] For TTF, we have Δy_t as our dependent variable and the independent variable is the first lag of y_t which is y_{t-1} where the coefficient of 0.0401 (see table A1) is statistically insignificant, therefore it is not significantly different from 0. Therefore, the variables are non-stationary. Similarly, RERF has original variables that are not stationary. However, both y_{t-1} coefficients for TTF (-0.97) and RERF (-0.764) are highly significant, thus indicating that the variables are stationary.

[33] For example, an ARIMA(2,1,3) is where 2 is the order of the autoregressive, 1 indicates the order of difference and 3 is the order of the moving average process.

[34] We also generated forecasts of 34 periods from 2017 to 2050, but these may not be reliable given the limitations of our observations, therefore we removed them.

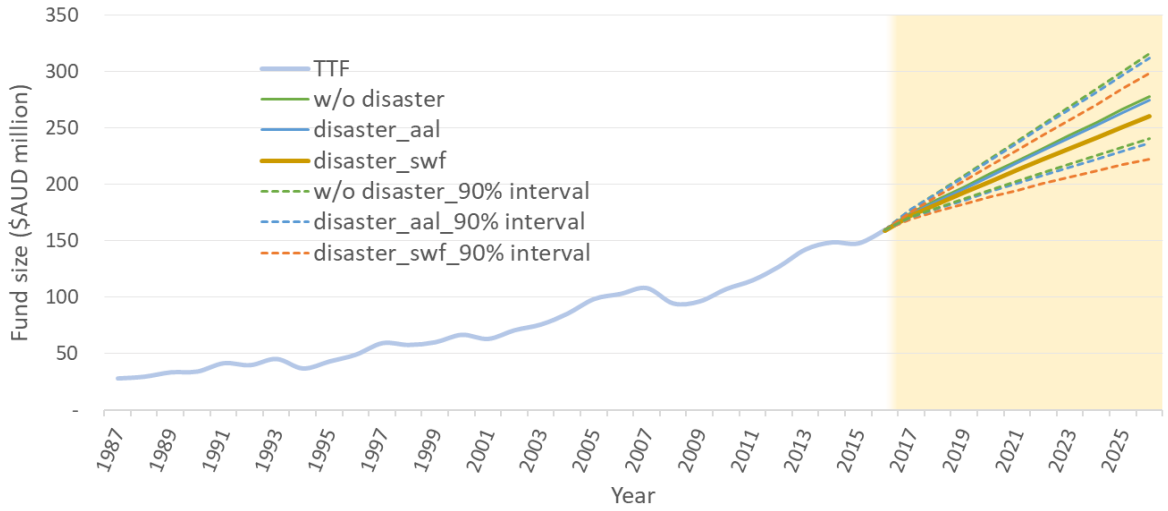

Figure 8: TTF forecast performance from 2017 to 2026 using the ARIMA model. Author's calculations and modelling. The disaster_aal is the TTF with incorporated contributions to the disaster fund using the adjusted AAL (fixed based on the calculated AAL in 2016 prices) as the annual contribution over time. The disaster_swf is the TTF with adjusted calculations to include the adjusted AAL as a percentage of the TTF, so that it changes overtime based on forecasted values of the TTF.

Like most other SWFs, both portfolios are vulnerable to economic shocks, as was evident during the global financial crisis of 2007-2008 (see figure 8 and figure 9). The *w/o disaster* (in green colour) is the expected path of the SWF without annual contributions into the disaster fund. The *disaster_aal* (unbroken blue colour) is the expected path where the TTF contributes the amount equivalent to the adjusted AAL annually into the disaster fund. Likewise, *disaster_swf* (unbroken red colour) represents the expected path of an alternative scenario with contributions to the disaster fund derived from the adjusted AAL as a percentage to SWF, which may vary over time depending on SWF size. Nevertheless, both the TTF and RERF have positive trends that indicate sustainability. We also plotted the ratio of the SWFs to

projected GDP to further examine how sustainable the size of the SWFs will be in relative to the GDP (see Appendix Figure 5 and Figure 6).

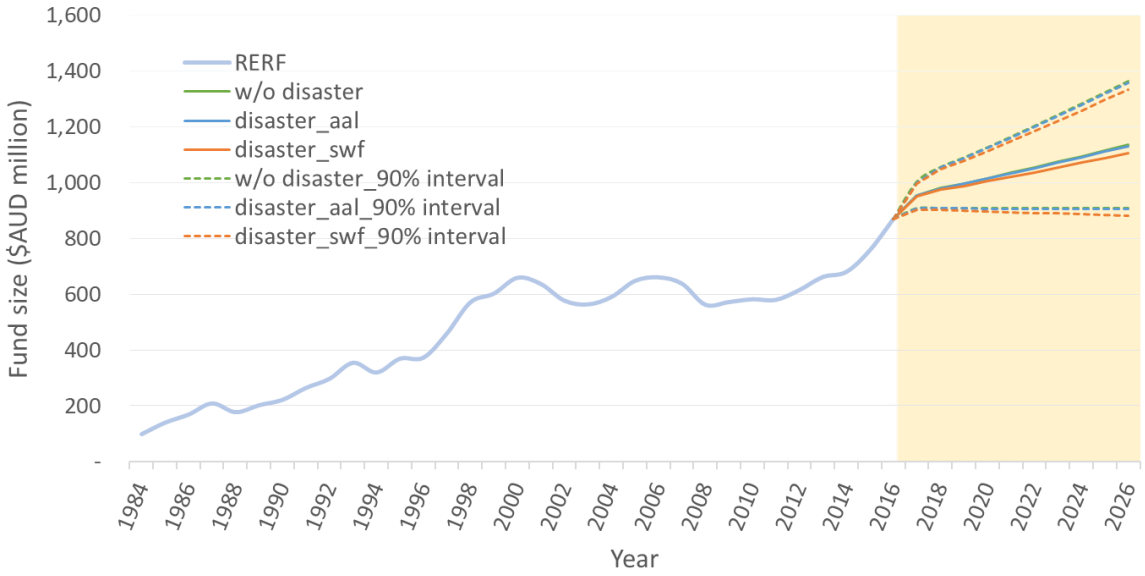

Figure 9: RERF forecast performance from 2017 to 2026 using the ARIMA model. Author's calculations and modelling. The disaster_aal is the TTF with incorporated contributions to the disaster fund using the adjusted AAL (fixed based on the calculated AAL in 2016 prices) as the annual contribution over time. The disaster_swf is the TTF with adjusted calculations to include the adjusted AAL as a percentage of the TTF, so that it changes overtime based on forecasted values of the TTF.

The impact of the global financial crises of 2008/2009 was evident in the sharp fall of GDP (see figure 3 for Tuvalu) in 2009 and SWF sizes (see figure 8 for the TTF and figure 9 for RERF) in those periods. In 2010 it quickly recovered, and continued to increase in 2011 (see figure 3 for the 2011 drought period) when it started to increase at a decreasing rate. Following the 2011 drought event, GDP levels decreased until they were hit by another disaster (see figure 3 for TC Pam). Similarly, the TTF quickly recovered from a drop in 2008 and 2009, bouncing back in

2010, and has been increasing over time.[35] It is noticeable in Figure A2 that the TTF received the highest donor contributions in 2010 (AUD$3.6 million) and 2011 (AUD$4 million), excluding the outlier in 1987 when TTF was established.[36] There were no contributions from the government in those years, hence giving room for the government to divert or reallocate monies into accelerating other priorities and development projects.

Under the current structures, the TTF and RERF experienced average annual drawdowns of 7.395% of GDP (or 2.06% of TTF size) and 5.3% of GDP (or 1.44% of RERF size), respectively. However, the alternative structures that contribute into disaster funds would increase annual drawdowns of the current structure by 2.6 (0.68% of TTF size) and 1.1 (0.29% of RERF size) percentage points for Tuvalu and Kiribati, respectively. On the other hand, the current average contributions into SWFs for the TTF is approximately 7.422% of GDP, which is only $0.011 million above the average annual drawdowns. By contrast, the average annual contributions into the RERF for Kiribati are far lower than the average annual drawdowns, by approximately $8.2 million. With the newly assumed responsibility of contributing into disaster funds, the alternative structures for drawdowns and contributions will change. The average annual drawdown as a percentage of the SWF would likely to increase by percentage points of 0.68 for the TTF and 0.29 for the RERF.

[35] It took 5 years for RERF to recover back to normal and progress onwards (see Figure 9). Part of the problem was that from 2003 to 2013, the government withdrew annually without contributing into the RERF.
[36] Over time, the average annual donor contributions into TTF is AUD$1.04 million.

6. Conclusion

Sovereign wealth funds are of national importance to small island states like Tuvalu and Kiribati in their development process which serves as buffers to the national budget, while also provide for responses to external economic shocks, but excludes natural disasters from its mandate. It could be argued that these SWFs should complement current preparation and response efforts to climatic disasters. The forecasts of sovereign wealth funds for Tuvalu and Kiribati are sustainable in the long-run. Based on SWFs' forecasts and imposed scenarios for the next 10 years with the inclusion of contributions to disasters in their operation, it shows positive trends that are sustainable for both TTF and RERF. Therefore, SWFs for Tuvalu and Kiribati can be instrumental in contributing to reducing disaster risks or in setting-up disaster funds devoted for disaster response and recovery. Establishing of disaster funds for preparedness and response is indispensable for small and low-lying atoll nations like Tuvalu and Kiribati given their vulnerability and exposure to climate change and climatic disasters.

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8. Appendix

Table A1: Dickey-Fuller Tests

	TTF ($D.y$ or Δy_t)	TTF ($D2.y$ or $\Delta\Delta y_t$)	RERF ($D.y$ or Δy_t)	RERF ($D2.y$ or $\Delta\Delta y_t$)
$L.y$ or y_{t-1}	0.0401		-0.0414	
	(0.0324)		(0.0367)	
$LD.y$ or Δy_{t-1}		-0.970***		-0.764***
		(0.202)		(0.180)
_cons	1562042.1	4595519.6***	40306992.2**	15530515.0*
	(2739254.4)	(1537342.6)	(18401249.2)	(8212269.5)
N	29	28	32	31

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: Authors' estimations from TTF and RERF data

Table A2: Selected ARIMA models for TTF

	ARIMA (1,1,0)	ARIMA (1,1,1)	ARIMA (0,1,1)
TTF			
_cons	4605834.9***	4558357.1***	4618443.1***
	(1508774.7)	(1546884.8)	(1505470.3)
ARMA			
L1.ar	0.0281	0.890**	
	(0.327)	(0.394)	
L1.ma		-1.000	0.0255
		(112.9)	(0.331)
sigma			
_cons	6382380.5***	6201262.6	6378794.1***
	(831111.7)	(349014100.7)	(827276.1)
N	29	29	29
AIC	997.07	996.40	997.07
BIC	1001.17	1000.87	1001.17

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: Authors' estimations from TTF and RERF data
Note: L1.ar is the first lag of the autoregressive part and L1.ma is the first lag of the moving average component.

Table A3: Selected ARIMA models for RERF

	ARIMA (1,1,3)	ARIMA (2,1,1)	ARIMA (2,1,2)
RERF			
_cons	20553135.9***	20304646.1***	21073122.4**
	(3413232.1)	(3578388.4)	(8967142.3)
ARMA			
L1.ar	0.677***	1.142***	0.970***
	(0.231)	(0.200)	(0.289)
L2.ar		-0.292	-0.862***
		(0.198)	(0.258)
L1.ma	-0.632*	-1.000***	-0.743**
	(0.367)	(0.310)	(0.377)
L2.ma	0.328		0.803
	(0.232)		(0.514)
L3.ma	-0.696***		
	(0.246)		
sigma			
_cons	33671439.8	36538536.3	35404298.1***
	.	.	(7327269.8)
N	32	32	32
AIC	1212.91	1214.91	1216.06
BIC	1220.24	1220.77	1224.86

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: Authors' estimations from RERF data
Note: L1.ar is the first lag of the autoregressive (AR) part, L2.ar is the second lag of the AR part, L1.ma is the first lag of the moving average (MA) component while L2.ma refers to the second lag of the MA part, and L3.ma is the third lag of the MA component.

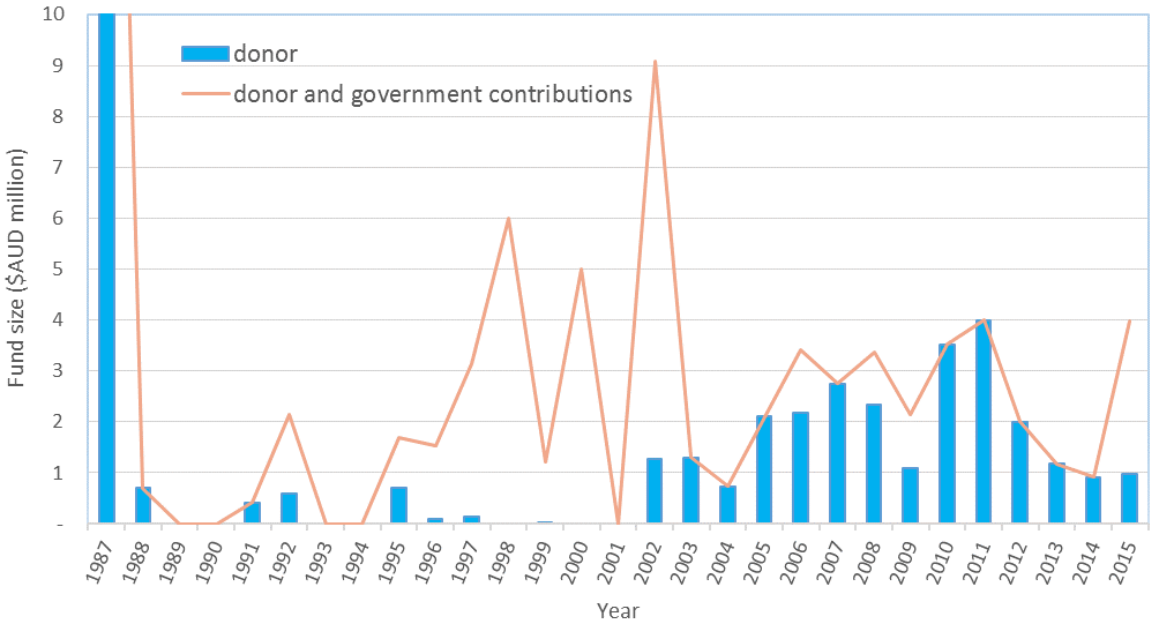

Figure A1: Contributions to the TTF. The author gathered data from TTF Advisory Committee Reports and National Budgets. Note that the outlier (1987) goes up to about AUD$24 million, which was when the TTF was established.

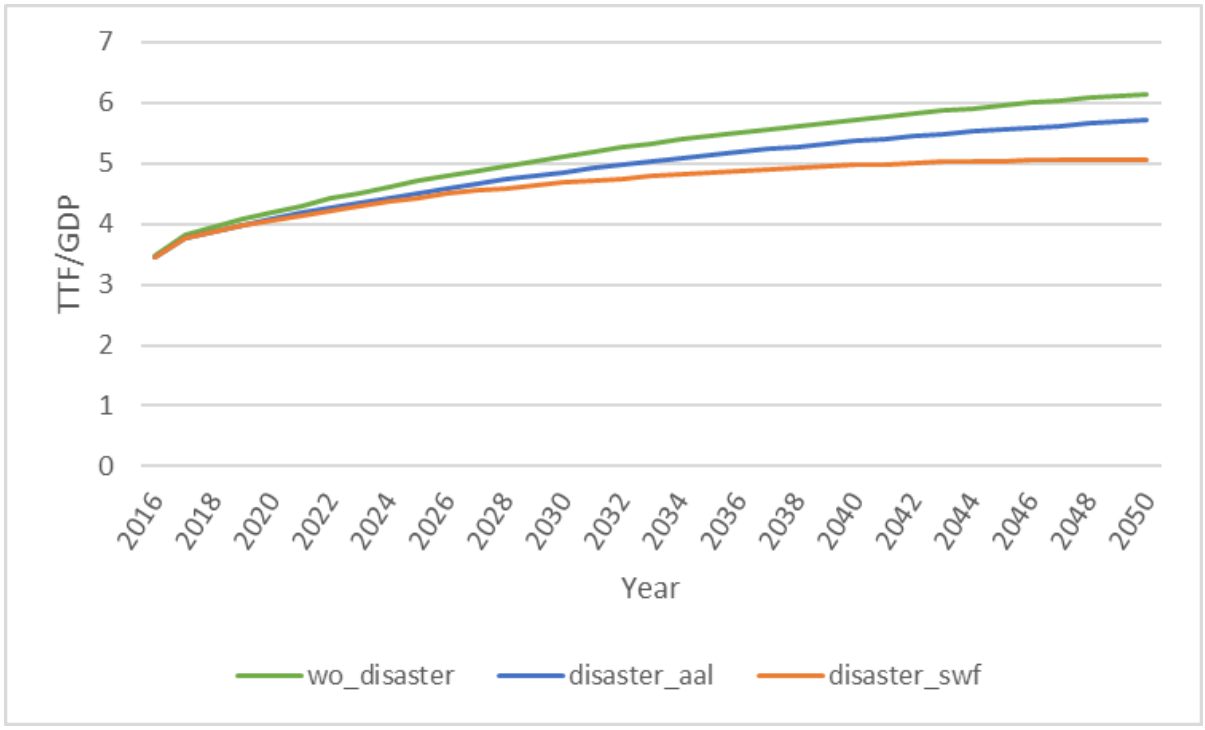

Figure A2: TTF vs GDP. Author's calculations and projections.

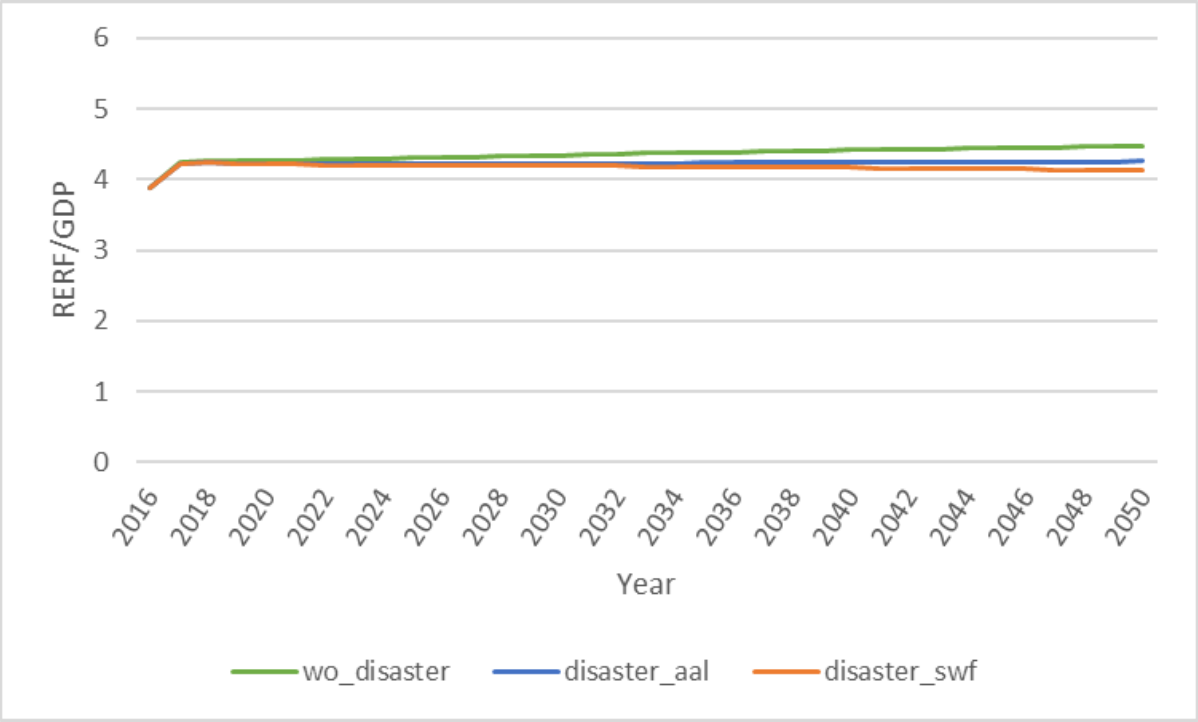

Figure A3: RERF vs GDP. Author's calculations and projections.