Rethinking the role of sovereign wealth funds in small island developing states: evidence from Tuvalu and Kiribati

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This paper examines the important role that can be played by sovereign wealth funds in financing of disaster risk management. The governments of Tuvalu and Kiribati are predicting climate change and natural disaster risks imposing increasing financial pressure on their economies. Having the required financial response in the aftermath of disasters is important to these low-lying atolls. The long-term sustainability of sovereign wealth funds in Kiribati and Tuvalu in contributing to ex post disaster risk management is examined.

Introduction

Small island developing states (SIDS) are very vulnerable to climatic disasters. Many studies point to the exposure of the Pacific islands countries to climatic risks due to their economic, geographical, and environmental characteristics (see World Bank 2014; OECD and World Bank 2016; Taupo et al. 2018), which can cause massive financial losses (Briguglio 1995; Heger et al. 2008; Klomp and Valckx 2014). Even cyclones that do not make landfall have economic impacts on these small islands, particularly Tuvalu (see Taupo and Noy 2017). An additional existential threat of climate change and sea level rise to these small and low-lying atoll states in the Pacific is the cost of protecting them against damage or moving the populations to safer ground (OECD and World Bank 2016).

Recently, response efforts in Tuvalu after the 2015 Tropical Cyclone Pam (TC Pam) were led by the government through its Disaster Committee, with support from humanitarian and bilateral partners. Based on assessments of the impact of the disaster, the government and regional and international organisations responded to key areas of humanitarian need. There was no disaster fund or any other liquid financial instrument in place at that time to assist in this endeavour, apart from the government's redirection of other expenditure lines.

I examine the feasibility of a funding mechanism for disaster relief based on a Sovereign Wealth Fund (SWF) model and (1) quantify the need for such a funding mechanism; (2) suggest a way to structure this mechanism based on the SWFs of Tuvalu and Kiribati; and (3) examine the long-term sustainability of this proposed funding arrangement. Autonomy, self-sufficiency, and predictability in relation to disaster response and recovery inspire this study.

As far as I am aware, no forecasts have been made of the sustainability of the Tuvalu Trust Fund (TTF) or the Kiribati Revenue

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Equalisation Fund (RERF) over the long run, nor is there any analysis of their feasibility and sustainability in providing financing mechanisms for disaster preparedness and response. The possibility of extending TTF coverage to disasters has been proposed but remains unquantified[1]; hence an aim of this study was to assess the feasibility and sustainability of these funds to support and contribute to disaster funds. Additionally, the study was intended to enhance understanding of potential options for disaster response for Tuvalu and Kiribati. The findings may be generalised to other Pacific or SIDS settings.

The next section provides background on available disaster financing instruments. The third section discusses the SWFs in Kiribati and Tuvalu; the fourth section describes the data and explains the methodology used in the analysis; fifth section details the results and discussion; and the conclusions are presented in the last section.

Climate change and disaster financing instruments

There are numerous financing instruments available for insuring against climate change and climatic disasters. Linnerooth-Bayer and Mechler (2009), for instance, discuss insurance and risk-financing mechanisms for managing disasters in developing countries.[2] One of the earliest instruments developed (in 2007) was the Caribbean Catastrophe Risk Insurance Facility (CCRIF), which is a pool of catastrophe insurance covering small island states in the Caribbean region, with a 'parametric trigger' for immediate insurance disbursements to affected states in the event of a disaster. To encourage and enforce disaster risk management and adaptation to climate change in the Pacific Islands Climate (PIC), the Pacific Catastrophe Assessment and Financing Initiative (PCRAFI) was devised to model disaster risks and assess financial options, aimed 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 within the Pacific region.[3] In reality, insurance is not a practical instrument for disaster response and recovery for very small PICs such as Tuvalu given their very small size (Taupo and Noy 2017).[4] Kiribati has an operating Insurance Corporation but it does not cover the sovereign risk and insurance penetration is comparatively low.[5]

Tuvalu received US$681,284 after TC Pam in 2015. The Tuvalu Government (2015) gathered a total of A$3.5 million from cash, in-kind, and pledge donations for relief and recovery efforts. Figure 1 displays spikes of net Official Development Assistance (ODA) for Tuvalu, corresponding to two state emergencies: the 2011 drought and TC Pam in

1 This issue was raised in several meetings in Tuvalu, including the TC Pam Meeting, National Summit for Tuvalu for the new National Sustainable Development Strategy for 2015–20 and the 2015 Tuvalu TTF Board Meeting (also mentioned in their 2015 TTFAC Report).

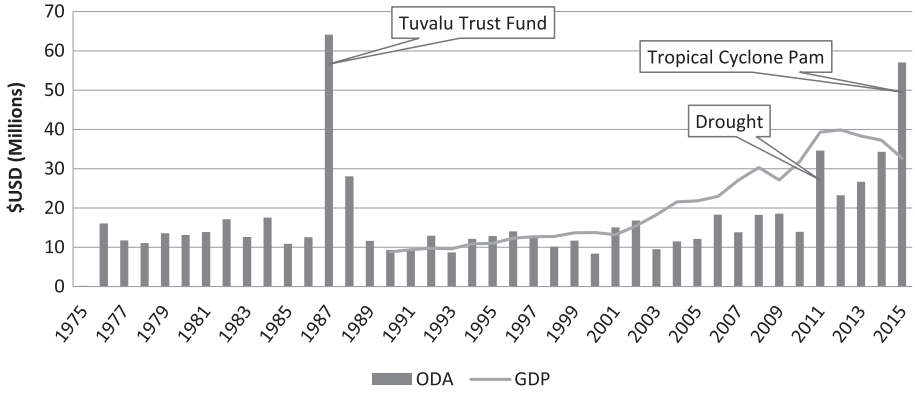
2 Some examples of risk financing instruments are the Proshika scheme which offers the Participatory Livestock Compensation Fund (PLCF), the Afat Vimo Disaster Insurance Program, the United States National Flood Insurance Program (NFIP), the Turkish Catastrophe Insurance Pool (TCIP), the Philippines 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.

3 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.

4 Apart from the unavailability of insurance mechanisms and insufficient resources (low income), 'charity hazard' is a concerning possibility deterring donors and the national government recipients (see Raschky and Weckhannemann 2007).

5 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.

Figure 1
ODA and GDP for Tuvalu



Source: Data are from the World Bank Databank website (http://databank.worldbank.org/data/).

2015. The year of the establishment of the TTF is represented by the highest spike in 1987. Figure 2 shows the ODA and GDP for Kiribati. Kiribati was also affected by the 2011 drought and TC Pam in 2015, but not to the extent of Tuvalu where a state of emergency was declared for both events.

PICs have received funding from other sources for climate change adaptation, mitigation, and resilience purposes. One of these sources is the National Adaptation Programmes of Action (NAPA), which has provided limited funding assistance to PICs such as Tuvalu, Kiribati, Samoa, the Solomon Islands, and Vanuatu to enable effective responses and adaptation to the effects of climate change.[6] Moreover, the Green Climate Fund (GCF) has approved a handful of projects for some PICs with the aim of assisting vulnerable countries in building climate resilience, climate adaptation, and mitigation.[7]

Relating to disaster financial mechanisms, Edmonds and Noy (2018) discuss risks in Pacific atoll islands and various financial instruments applicable to both ex ante and ex post disaster risk management: (1) post-disaster budget provisions; (2) offshore funds; (3) contingent credit lines and multilateral loans and grants; (4) insurance for public assets; (5) private insurance; (6) sovereign insurance, and (7) regional pooling of sovereign insurance.

Sovereign wealth funds

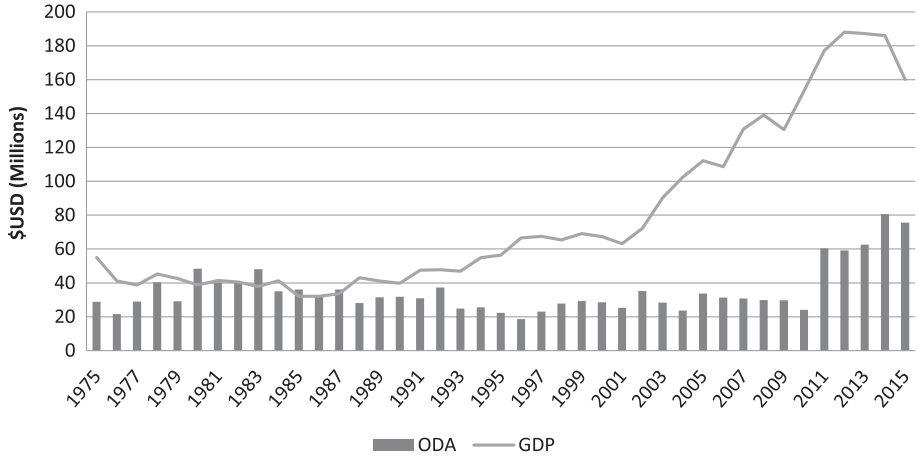
Alhashel (2015) discusses the recent popularity of SWFs, which in 2014 had amassed up to US$6.65 trillion.[8] Balding (2012) and Clark et al. (2013) focus on the management, politics, and economics behind them. However,

6 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).

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

8 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 15 November 2016, the total SWFs added up to US$7.3957 trillion, which is represented by Total oil and gas related (US$4.3213 trillion) and Total others (US$3.0744 trillion). In comparison, the US$0.75 trillion increase from 2014 to 2016 is 11.21 per cent.

Figure 2
ODA and GDP for Kiribati



Source: Data are from the World Bank Databank website (http://databank.worldbank.org/data/).

there is very limited research on SWFs in the PICs.[9] Several PICs, including Kiribati, Tuvalu, Timor-Leste, Papua New Guinea, Nauru, Tonga, the Marshall Islands, Micronesia, and Palau have SWFs established from revenue sources including non-renewable resources, revenue windfalls, and donor contributions. These funds have served their governments for short-term budget stabilisation, long-term savings, and the improvement of self-reliance (see Le Borgne and Medas 2007).

In general, structures (legal, institutional, and governance) and investment strategies vary between the SWFs. The SWFs cover economic disturbances and long-term liabilities rather than natural shocks. Given the current concerns over climate change and climatic disasters in PICs, the focus needs to be directed into the setting up of disaster funds, if there are none, or contributing to existing disaster budget allocations.[10]

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.[11] The 'Santiago Principles' consist of 24 Generally Accepted Principles and Practises (GAPP) that are supported by members of the International Working Group of Sovereign Wealth Funds (IWG)[12] as guidelines for proper, prudent, and sound management of SWFs. The International Working Group of Sovereign Wealth Funds (2008) broadly arranged the 24 GAPP into three pillars, namely: (1) legal framework, objectives, and coordination with macroeconomic policies; (2) institutional framework and governance structure, and

9 Limited quantitative research on SWFs in Pacific Island Countries is partly due to strict access to data.
10 Beyond this endeavour is the aim to sustain disaster funds into the long-term.
11 The Principles were established in 2008 with inputs from the IMF, World Bank, OECD, and others.
12 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.

Table 1
Compliance with the Santiago principles by fund for selected PICs

	Countries (in descending order of compliance)			
	Timor-Leste (TLPF)	Tuvalu (TTF)	FSM and RMI (CTFs)	Kiribati (RERF)
2011 SWF scoreboard[1]	73			
2013 SWF scoreboard[1]	85			35
2014 compliance index rating[2]	A			
2015 rating[3]				
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

[1] Scores (with a 100-point scale) calculated by Bagnall and Truman (2011; 2013).
[2] Santiago compliance index rating computed by GeoEconomica (2014).
[3] The rating classifications (good, neutral, poor) determined by Edmonds (2015). '–' refers to insufficient information.

(3) investment and risk management framework.[13]

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 did not perform well in 2013 relative to the other 48 SWFs assessed, being 19 points below the SWF average score (Bagnall and Truman 2013). The TTF has not been thoroughly assessed in comparison to other SWFs at the international level, but only at the Pacific regional level by Edmonds (2015), where he divided the 24 GAPP into seven[14] thematic areas and ranked the SWFs 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 that Tuvalu's TTF was performing well overall in 2015, while underperforming in categorised area 'six'. Kiribati's RERF was performing poorly in categorised areas 'four', 'six', and 'seven'. The identified weaknesses should be key focus areas for improvement. Tuvalu on the other hand, requires a thorough assessment of its compliance with the 'Santiago Principles'. However, with the inclusion of TTF contributions to the disaster fund, it will most likely deviate from the 'Santiago Principles'.

Cabezon et al. (2019) discussed the vulnerability of PICs to natural disasters and climate change, while constructing a framework to enhance both ex ante and ex post resilience to

13 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) 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'.

14 The seven categorised areas are shown in Table 1.

natural disasters. Duncan et al. (1995) point out the imperativeness for aid-dependent economies in the South Pacific Islands to know that: (1) SWFs serve useful functions such as enhancing savings, stabilising and sterilising large natural resource revenues; (2) these funds are vulnerable to political forces and that mechanisms to check these influences should be in place such as statutory independence, broadly based board membership and public reporting; and (3) the need for careful selection of decision rules on drawdowns from the funds to avoid disrupting fiscal management.

Resource revenues in some developing countries and high income countries have been mishandled on various occasions due to waste, corruption, macroeconomic instability, civil conflict, and distortion of political processes (Duncan 2010). Some examples in the Pacific are: the mismanagement of the PNG Mineral Revenue Stabilisation Fund; the probable disaster given government overriding of constraints above estimated sustainable levels of the Timor-Leste's Petroleum Fund on the verge of ceasing oil extraction; and the Nauru Phosphate Royalties Trust that was built from phosphate mining like Kiribati's RERF, but was unsuccessful later due to mismanagement and corruption (Duncan 2011; Ouoba 2016; Doraisami 2018; Gale 2019).

Tuvalu trust fund and Kiribati's revenue equalisation reserve fund

The TTF is guided by its International Agreement for the Tuvalu Trust Fund with advice and monitoring from the TTF Advisory Committee (TTFAC) and Fund managers. According to the Tuvalu Government (2008:6):'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' The RERF is a special fund under Section 107 of the Constitution whereby the Minister of Finance can directly wind up the Fund under section 13(2)(b) of the Public Finance (Control and Audit) Act.[15] Although we have not sighted[16] the objectives, mission, and policy purposes of the RERF, both the TTF and RERF support their governments fiscally, providing reliable revenue sources (fiscal buffers) to offset recurrent national budget shortfalls and occasionally smoothing out market fluctuations.[17]

The TTF was formed in 1987 from investments from donors and the national government, while the RERF was established solely from the national government's contributions (Ministry of Finance and Economic Development 2016; Toatu 1993; Van Trease 1993; TTFAC Secretariat 2006, 2015; Tuvalu Trust Fund Board 2007). The current TTF structure consists of contributions from the original donors and subsequent contributors, including the Tuvalu government. There are no rules on the amount of annual contributions to the funds. Withdrawals from the RERF operate on a minimal draw-down principle that obviously has limited enforcement in some years, while often capital accumulation and reinvesting annual earnings is preferred.

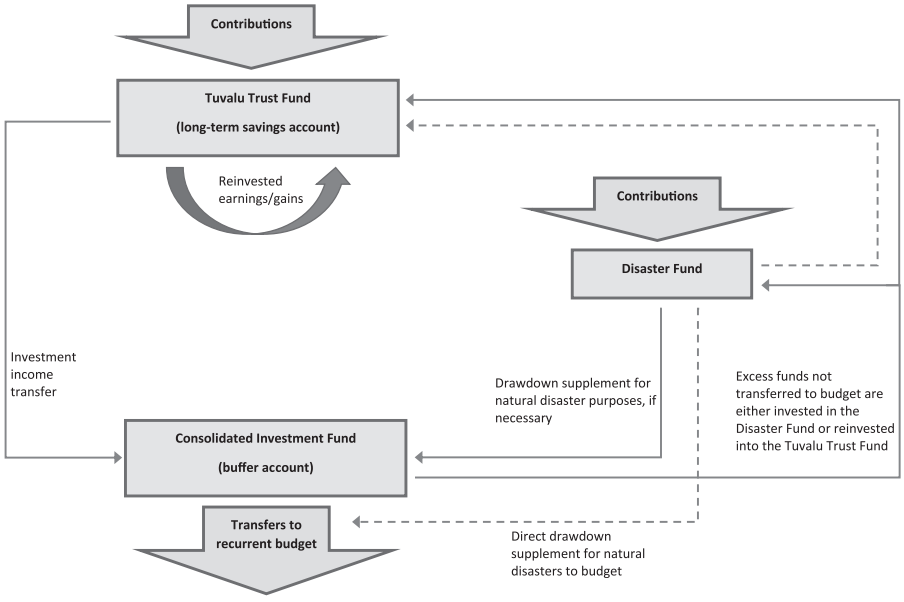
Positive distributions or investment income from the TTF are transferred to the Consolidated Investment Fund (CIF) for disbursement. The CIF acts as a buffer in the current

15 The Constitution and the Public Finance (Control and Audit) Act were both accessed on 21 March 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 SWFs in the Pacific and how they are distinguished from one another.

16 We assume that the information for the RERF is not publicly available or does not exist. However, in principle, the use of the RERF is reflected in their national budgets.

17 The TTFAC Secretariat (2015:11) 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 (for example, licence fees for fishing and '.tv, and the ROC budget support payments); (2) volume of traded items (for example, fish harvested under a licence agreement); (3) market prices of traded items (for example, VDS fishing days); (4) timing of cash flows (for example, sales of various fishing licences); (5) capital markets (for example, affecting investment returns); (6) demand driven, loosely constrained expenditure policies; and the incidence of random natural disasters affecting Tuvalu (for example, Cyclone Pam).'

Figure 3
Alternative Tuvalu trust fund resource flow



structure.[18] 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 3 shows a potential alternative structure for the SWF, to connect the TTF to a disaster fund. In this proposal, the TTF will provide support to the disaster fund via contributions.

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 and Economic Development 2016).[19] Kiribati already has a disaster fund in place.

In managing the performance of these funds, global market uncertainties are an issue. However, Tuvalu and Kiribati are mindful that strong fiscal performance can be achieved through fiscal surpluses, increases in revenues from grants and fishing licences, and increasing contributions into their funds. Apart from other revenue sources, both countries earn incomes from tuna through fisheries agreements for foreign vessels to fish in their sea territories.

Data and method

We used time series data on the TTF and RERF. Data were yearly from financial years 1987 to 2016 for Tuvalu and from 1984 to 2016 for Kiribati. Data on the TTF were gathered from the TTF Secretariat of the Tuvalu Government, while RERF annual values were

18 Other Pacific Islands without SWFs and buffer accounts meet national budget deficits by borrowing at high interest rates.
19 In the wake of TC Pam, the political will to establish a disaster fund known as the 'Tuvalu Survival Fund' surfaced.

acquired from Kiribati's Ministry of Finance and Economic Development.[20] Annual reports on the Funds and the national budgets complemented these data.[21]

We employed the autoregressive integrated moving average (ARIMA) model to forecast the future values of the TTF and RERF from the time series data. The ARIMA model allows both autoregressive (AR) components as well as moving average (MA) components and eliminates non-stationarity. This method points to the usefulness of modelling AR components as modelling the 'change since last time' and modelling MA components captures smoothed trends in the data.

The ARIMA model was proposed by Box and Jenkins (1970) as an extension of the autoregressive moving average (ARMA) model—which is a combination of AR and MA models (thus it combines 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 for example, Diebold 2006).[22] The first component in the ARMA model is the AR model, where the value in a 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 at 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 and Jenkins 1970, 1976; Hyndman and Athanasopoulos 2014). Therefore, our $ARIMA(p, d, q)$ represents a model with p autoregressive lags, q moving average lags, and a difference in the order of d as given in $y_i^d = \mu + \sum_{i=1}^{p} \gamma_i y_{t-i}^d + \varepsilon_t + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i}$. Here, values of the dependent variable y, measured in time,t, which 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 $t-q$.

Stationarity is a requirement in modelling an $ARMA(p, q)$ process, where the mean and variance do not change over time and the process does not have trends. When these conditions are not met, that is, non-stationarity, the ARMA model cannot be used. In that case we turn to the Box–Jenkins procedures (see Box and Jenkins 1976), using an ARIMA model instead of ARMA.[23] We followed the Box–Jenkins method for ARIMA model selection in the diagnostics, where we use the Dickey–Fuller test for stationarity,[24] autocorrelation function (ACF) and partial ACF (PACF) for correlations, and Akaike information criterion (AIC) and the Bayesian Information Criterion (BIC) measures were used to test for goodness of fit of the model (see Box and Jenkins 1976; Makridakis et al. 1997).

Results and discussion

We used the risk estimates supplied by PCRAFI for Tuvalu and Kiribati to determine the required contributions into the disaster funds. The computed average annual loss (AAL) from PCRAFI estimates the annual economic losses averaged over the 10,000

20 Data for the RERF were gathered from the Ministry of Finance and Economic Development and their official website (http://www.mfed.gov.ki/).
21 Other Pacific Islands with SWFs were also approached for their data, but declined.
22 ARIMA is sometimes referred to as the integrated ARMA model. See Diebold (2006) for detailed discussion on the AR, MA, and ARMA models.
23 The Box–Jenkins procedures follow 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 and Olanrewaju (2015) employed these methods.
24 This procedure requires the differencing of the time series until it is stationary; this will ensure the removal of any trend or seasonal components.

Table 2
Dickey–Fuller tests

	TTF ($D \cdot y$ or Δy_t)	TTF ($D2 \cdot y$ or $\Delta\Delta y_t$)	RERF ($D \cdot y$ or Δy_t)	RERF ($D2 \cdot y$ or $\Delta\Delta y_t$)
$L \cdot y$ or y_{t-1}	0.0401		−0.0414	
	(0.0324)		(0.0367)	
$LD \cdot y$ or Δy_{t-1}		−0.970***		−0.764***
		(0.202)		(0.180)
_cons	1,562,042.1	4,595,519.6***	40,306,992.2**	15,530,515.0*
	(2,739,254.4)	(1,537,342.6)	(18,401,249.2)	(8,212,269.5)
N	29	28	32	31

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

realisations of the next-year activity. These computed values of A$319,738 and A$379,403 for Tuvalu and Kiribati, respectively, were used as the appropriate levels of financial support (or contributions) from SWFs into disaster funds for expected disasters in Tuvalu and Kiribati.[25]

Under these conditions, TTF and RERF would have amassed estimated contributions to their disaster funds at the end of the financial year 2026 in the order of A$3.2 million and A$3.8 million, respectively.[26] An alternative condition is where contributions to the disaster fund are derived from the adjusted AAL as a percentage to the SWF, which may vary over time depending on the size of the SWF. Under this alternative scenario, the TTF and RERF would amass estimated contributions to their disaster funds at the end of the financial year 2026 in the order of A$15.6 million and A$26.2 million, respectively. In the following section, we present the forecasting results for the two SWFs together with scenarios including estimated contributions to their disaster funds using the forecasting approach.

The Dickey–Fuller tests for stationarity for the TTF and RERF data showed that the original variables are not stationary but that the differences variables are stationary (see Table 2).[27] Therefore, we resorted to the ARIMA model where we used differences $d = 1$. Based on the selection criteria (see Table 3), we chose parsimonious models of ARIMA(1,1,1)[28] and ARIMA(1,1,3) to forecast the TTF and RERF, respectively, since they both have significant coefficients and the lowest AIC and BIC that indicate goodness of fit of the models.

Using the ARIMA model with 30 and 33 observations for the TTF and RERF respectively, we generated forecasts for ten periods (from 2017 to 2026) with 90 per cent confidence limits (see Tables 4 and 5).[29] As expected, the forecast bands widen into the

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

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

27 For the TTF, Δy_t is the 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 2) 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 the TTF (−0.97) and the RERF (−0.764) are highly significant, thus indicating that the variables are stationary.

28 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.

29 Forecasts of 34 periods from 2017 to 2050 were also generated, but these may not be reliable given the limitations of our observations, therefore we removed them.

Table 3
Selected ARIMA models for TTF and RERF

	TTF			RERF		
	ARIMA (1,1,0)	ARIMA (1,1,1)	ARIMA (0,1,1)	ARIMA (1,1,3)	ARIMA (2,1,1)	ARIMA (2,1,2)
Cons	4,605,834.9***	4,558,357.1***	4,618,443.1***	20,553,135.9***	20,304,646.1***	21,073,122.4**
	(1,508,774.7)	(1,546,884.8)	(1,505,470.3)	(3,413,232.1)	(3,578,388.4)	(8,967,142.3)
ARMA						
L1.ar	0.0281	0.890**		0.677***	1.142***	0.970***
	(0.327)	(0.394)		(0.231)	(0.200)	(0.289)
L2.ar					−0.292	−0.862***
					(0.198)	(0.258)
L1.ma		−1.000	0.0255	−0.632*	−1.000***	−0.743**
		(112.9)	(0.331)	(0.367)	(0.310)	(0.377)
L2.ma				0.328		0.803
				(0.232)		(0.514)
L3.ma				−0.696***		
				(0.246)		
sigma						
_cons	6,382,380.5***	6,201,262.6	6,378,794.1***	33,671,439.8	36,538,536.3	35,404,298.1***
	(831,111.7)	(349,014,100.7)	(827,276.1)			(7,327,269.8)
N	29	29	29	32	32	32
AIC	997.07	996.40	997.07	1212.91	1214.91	1216.06
BIC	1001.17	1000.87	1001.17	1220.24	1220.77	1224.86

Source: Author's estimations from RERF data. Note that 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. Standard errors in parentheses. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

Table 4
TTF forecast performance 2017–26 using the ARIMA model (A$ millions)

Year	w/o disaster	Disaster aal	Disaster swf	w/o disaster 90% interval upper	w/o disaster 90% interval lower	Disaster aal 90% interval upper	Disaster aal 90% interval lower	Disaster swf 90% interval upper	Disaster swf 90% interval lower
2010	107.3	107.3	107.3	107.3	107.3	107.3	107.3	107.3	107.3
2011	115.1	115.1	115.1	115.1	115.1	115.1	115.1	115.1	115.1
2012	127.3	127.3	127.3	127.3	127.3	127.3	127.3	127.3	127.3
2013	142.6	142.6	142.6	142.6	142.6	142.6	142.6	142.6	142.6
2014	148.9	148.9	148.9	148.9	148.9	148.9	148.9	148.9	148.9
2015	148.0	148.0	148.0	148.0	148.0	148.0	148.0	148.0	148.0
2016	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0
2017	174.8	172.6	172.6	178.2	171.4	176.0	169.2	175.9	169.2
2018	186.3	183.0	182.8	193.1	179.5	189.8	176.2	189.6	176.1
2019	197.8	193.4	192.9	208.1	187.4	203.7	183.0	203.3	182.5
2020	209.2	203.7	202.8	223.3	195.2	217.8	189.7	216.9	188.8
2021	220.7	214.1	212.6	238.5	202.9	231.9	196.3	230.4	194.8
2022	232.2	224.5	222.2	253.9	210.5	246.2	202.8	243.9	200.5
2023	243.6	234.8	231.9	269.3	218.0	260.5	209.2	257.5	206.2
2024	255.1	245.2	241.4	284.8	225.5	274.8	215.5	271.0	211.7
2025	266.6	255.6	250.9	300.3	232.9	289.3	221.8	284.7	217.2
2026	278.1	265.9	260.3	315.9	240.2	303.8	228.1	298.2	222.5

Source: 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. The *Disaster swf* is the TTF with adjusted calculations to include the adjusted AAL as a percentage of the TTF, so that it changes over time based on forecasted values of the TTF.

forecast horizon. These forecasts show how SWFs are likely to perform with or without the inclusion of contributions to disaster funds.

Like most SWFs, both portfolios are vulnerable to economic shocks, as was evident during the global financial crisis of 2007–08 (see Tables 4 and 5). The *w/o disaster* is the expected path of the SWF without annual contributions into the disaster fund. The *Disaster_aal* is the expected path where the TTF contributes the amount equivalent to the adjusted AAL annually into the disaster fund. Likewise, *Disaster_swf* 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, which confirmed how sustainable the SWFs will be relative to the GDP.

The impact of the global financial crisis of 2008–09 is evident in the sharp fall of the GDP in 2009 and in the size of the SWFs in that period (see Table 4 for the TTF and Table 5 for the RERF). In 2010 the GDP quickly recovered and continued to increase in 2011 during the drought period when it increased at a declining rate. Following the 2011 drought event, GDP levels declined until they were hit by another disaster. Similarly, the TTF quickly recovered from the drop in 2008 and 2009, bouncing back in 2010, and has been increasing since.[30] The TTF received the highest donor contributions in 2010 (A$3.6 million) and 2011 (A$4 million), excluding the outlier in 1987 when the TTF was

30 It took five years for the RERF to recover. Part of the problem was that from 2003 to 2013 the government made withdrawals annually without contributing into the RERF.

Table 5
RERF forecast performance 2017 to 2026 using the ARIMA model (A$ millions)

Year	w/o disaster	Disaster aal	Disaster swf	w/o disaster 90% interval upper	w/o disaster 90% interval lower	Disaster aal 90% interval upper	Disaster aal 90% interval lower	Disaster swf 90% interval upper	Disaster swf 90% interval lower
2010	107.3	107.3	107.3	107.3	107.3	107.3	107.3	107.3	107.3
2011	115.1	115.1	115.1	115.1	115.1	115.1	115.1	115.1	115.1
2012	127.3	127.3	127.3	127.3	127.3	127.3	127.3	127.3	127.3
2013	142.6	142.6	142.6	142.6	142.6	142.6	142.6	142.6	142.6
2014	148.9	148.9	148.9	148.9	148.9	148.9	148.9	148.9	148.9
2015	148.0	148.0	148.0	148.0	148.0	148.0	148.0	148.0	148.0
2016	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0	160.0
2017	174.8	172.6	172.6	178.2	171.4	176.0	169.2	175.9	169.2
2018	186.3	183.0	182.8	193.1	179.5	189.8	176.2	189.6	176.1
2019	197.8	193.4	192.9	208.1	187.4	203.7	183.0	203.3	182.5
2020	209.2	203.7	202.8	223.3	195.2	217.8	189.7	216.9	188.8
2021	220.7	214.1	212.6	238.5	202.9	231.9	196.3	230.4	194.8
2022	232.2	224.5	222.2	253.9	210.5	246.2	202.8	243.9	200.5
2023	243.6	234.8	231.9	269.3	218.0	260.5	209.2	257.5	206.2
2024	255.1	245.2	241.4	284.8	225.5	274.8	215.5	271.0	211.7
2025	266.6	255.6	250.9	300.3	232.9	289.3	221.8	284.7	217.2
2026	278.1	265.9	260.3	315.9	240.2	303.8	228.1	298.2	222.5

Source: Author's calculations and modelling. The *Disaster aal* is the RERF with incorporated contributions to the disaster fund using the adjusted AAL (fixed, based on the calculated AAL in 2016 prices) as the annual contribution. The *Disaster swf* is the RERF with adjusted calculations to include the adjusted AAL as a percentage of the RERF, so that it changes over time based on forecasted values of the RERF.

established.[31] There were no contributions from the government in those years, giving room for the government to divert or reallocate monies into accelerating other priorities and development projects.

Under current structures, the TTF and RERF experienced average annual drawdowns of 7.4 per cent of GDP (or 2.06 per cent of TTF size) and 5.3 per cent of GDP (or 1.44 per cent of RERF size), respectively. However, the alternative structures that contribute into disaster funds would increase annual drawdowns of the current structure by 2.6 per cent (0.68 per cent of TTF size) and 1.1 per cent (0.29 per cent of RERF size) for Tuvalu and Kiribati, respectively.

The current average contributions into the TTF are approximately 7.42 per cent of GDP, which is only A$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 A$8.2 million. With the 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 increase by 0.68 per cent for the TTF and by 0.29 per cent for the RERF.

Conclusions

Sovereign wealth funds can be of importance to small island states such as Tuvalu and Kiribati in their development processes, including responses to external economic shocks. SWFs could also complement

31 Over time the average annual donor contributions into the TTF is A$1.04 million.

preparations for and responses to climatic disasters. When using the estimated AALs by PCRAFI, statistical forecasting shows that the SWFs of Tuvalu and Kiribati are likely to be large enough to cover the probable costs of disasters and to be sustainable in the long run. The SWFs' forecasts and imposed scenarios for the next ten years, with the inclusion of contributions to disasters in their operation, show positive trends that are sustainable for both the TTF and the RERF. Therefore, SWFs for Tuvalu and Kiribati can be instrumental in contributing to reducing disaster risks or in setting-up disaster funds devoted to disaster response and recovery.

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