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Abstract

Resilience is the ability of an entity to manage a destabilizing shock or rise in pressure. The recently published State Resilience Index (SRI) includes ecological resilience along with several other "pillars" of state resilience. Given that indicators of subjective well-being (SWB) are increasingly accepted as a measure of national performance and as a standard for evaluating public policy, this paper investigates whether national SWB scores capture the ecological resilience dimension of national performance. Regression analysis of data for 124 countries reveals that SWB is significantly positively related to the ecological pillar of state resilience as well as some of its sub-pillars, but not others. In multivariate regressions, significant sub-pillars of ecological resilience are agricultural productivity, low levels of pollution, and freshwater availability, but not ecosystem health, long-term climate stability and biodiversity. The evidence is taken to suggest that SWB captures the more tangible aspects of the state of the environment rather than latent ecological threats whose full consequences will mainly be felt in the future. To capture latent ecological threats, SWB-based performance measures will therefore have to be complemented by more forward-looking indicators of ecological resilience.

Keywords: ecological resilience; subjective well-being; national performance; environmental threat; forward-looking

JEL Classification: Q20; Q50; I31

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1. Introduction

Over the past few decades, the world has seen a number of large-scale shocks (e.g., the global financial crisis in 2009 and the COVID-19 pandemic) and rising pressures (e.g., climate change and the loss of biodiversity). In spite of ongoing efforts to reduce the likelihood and severity of shocks and the magnitude of pressures (e.g., through regulation of the financial sector, the development of vaccines, and the mitigation of greenhouse gases), it seems that the levels of crisis prevention and pressure reduction attained so far fall short of internationally accepted targets – as evidenced by the recently documented failure to achieve the majority of the United Nations' Sustainable Development Goals, in particular with respect to climate change and biodiversity (United Nations 2023).

Acknowledging that global risks and pressures are unlikely to be eradicated, the concept, measurement, and promotion of resilience – the ability of an entity to manage a destabilizing shock or rise in pressure – have received increasing attention in recent years (for a comprehensive account see Chandler and Coaffee 2017).[1] While resilience (or the lack thereof) is a characteristic of entities at the micro, meso and macro levels (Rose and Krausmann 2013), resilience of nations (state resilience) is of particular importance given nation-states' responsibility to protect the well-being of their citizens in the face of global challenges (Brown 2022,). Accordingly, emphasis on resilience has also swelled in communications from international organizations and institutions (e.g. European Union 2017).

The recently published State Resilience Index (SRI) provides a comprehensive framework and measure of nations' resilience with respect to several dimensions or "pillars", including environmental and ecological resilience. The SRI was designed as a tool to identify capacities and capabilities of countries under stress that allow them to prepare, manage, and recover from a crisis, relative to the severity of that crisis (Fund for Peace 2022).

This paper conceives of the capacity and capability of a country to cope with crises as a major dimension of that country's economic, social, and environmental performance. From that perspective, conceptualizing and measuring state resilience aligns with more general efforts to identify indicators of national performance beyond conventional measures of economic output and consumption (Fleurbaey 2009, Stiglitz et al. 2009).

[1] The Organisation for Economic Co-operation and Development (OECD) provides a more detailed definition of resilience as "the ability of individuals, communities and states and their institutions to absorb and recover from shocks, whilst positively adapting and transforming their structures and means for living in the face of long-term changes and uncertainty." See OECD ((2013).

National performance measures can be categorized as either objective or subjective (Stiglitz et al. 2009). While the SRI and its constituent indicators fall into the former category, a subjective measure that has received increasing attention in recent years is subjective well-being (SWB).[2] Proponents of using SWB scores conceive of them as capturing various dimensions of national performance and aggregating them into a single indicator of how well a society is doing (e.g., Clark 2016, Frijters and Krekel 2021). In support of this view, SWB has been found to be positively related to high levels and low fluctuation of aggregate income, low rates of unemployment and inflation, and high quality of government (see Clark 2018 for a recent review. As will be discussed in the next section, SWB also captures several dimensions of environmental quality – but may fail to capture others. In particular, environmental characteristics whose effects are of a latent rather than manifest nature may be poorly represented by SWB (see below).

The present paper ties in with this ambiguity as to which environmental and ecological characteristics are captured by SWB and which are not. The paper considers the State Resilience Index, putting the focus on the environmental and ecological pillar and its various sub-pillars. Based on the differentiation between sub-pillars that include more manifest or tangible characteristics (*environmental health*) and others that include more latent or less tangible characteristics (*ecosystem vitality*), the paper tests the hypothesis that national SWB scores capture the former but fail to capture the latter.

Multivariate regression analysis of data for 124 countries reveals that SWB is significantly positively related to the Environment-Ecology pillar of state resilience as well as the sub-pillars Agricultural Productivity, (low levels of) Pollution, and Freshwater Availability, but not Ecosystem Health, Long-Term Climate Stability, and Biodiversity. The evidence is taken to suggest that SWB captures the more tangible aspects of the state of the environment rather than latent ecological threats whose full consequences will mainly be felt in the future. To capture latent ecological threats, SWB-based performance measures will therefore have to be complemented by more forward-looking indicators of ecological resilience.

The paper is organized as follows. Section 2 reviews the pertinent SWB literature and identifies the research question. Section 3 describes the methods and data used. Section 4 presents and discusses the results. Section 5 concludes.

[2] Measures of SWB are regularly elicited in large-scale representative surveys, and national SWB scores and rankings have been published in the United Nations' annual World Happiness Report since 2012. More recently, SWB has entered the official statistics and policy-making of several countries. See Frijters and Krekel (2021) for a comprehensive account of the history, theory, measurement, and implementation of SWB as a means of policy-appraisal.

2. Background and Research Question

The literature on SWB and the environment has found SWB to be related to several environmental characteristics (see Maddison et al. 2020 for a comprehensive account). This section reviews the major dimensions of the SWB-environment relationship.

2.1 Well-Being and Air Pollution

One of the environmental issues most thoroughly studied in the well-being literature is air pollution. Air pollution can affect subjective well-being as it leads to a wide range of respiratory and cardiovascular problems that negatively affect subjective well-being (Gouveia and Maisonet, 2005). Some of the studies on air pollution and subjective well-being were among the first to put a monetary value on the well-being costs of environmental degradation by calculating the hypothetical amount of money (income) that would compensate an individual for the well-being loss arising from pollution (Welsch 2002).

While most of the early studies of air pollution and well-being (e.g., Welsch 2002, 2006) used aggregate levels of pollution and well-being by country and year, more recent work is characterized by a higher spatial and temporal resolution of pollution data and by focusing on the well-being of the individuals affected by the pollution. One such study combined individual-level well-being data with data for sulfur dioxide (SO_2) at the county level for Germany (Luechinger 2009). Since the data used comes from a longitudinal panel survey, which follows individuals over several years, it was possible to control for individual fixed effects and to focus on changes in the pollution an individual was exposed to rather than focusing on differences between individuals. Moreover, using instrumental-variable techniques, it was possible to rule out that results were biased by people's deliberately moving to less polluted places. Overall, the study thus established a causal effect of air pollution on well-being, rather than just a correlation. Similar studies were undertaken with respect to many more countries, for example Australia (Ambrey et al. 2014) and the United States (Levinson 2012), and in a multi-country setting for Europe (Ferreira et al. 2013), all of them finding significant effects of air pollution on well-being (for a comprehensive discussion, see Levinson 2020).

2.2 Well-Being and Climate Parameters

Well-being effects of climate change can be captured by studying how well-being varies with spatial and temporal variation in climate parameters that are likely to change in the future, such as levels and seasonal patterns of temperature or precipitation. One of the first studies on climate parameters and SWB estimated the association between extreme temperatures and subjective well-being in 67 countries over the period 1997-2000 and found that the lower the minimum temperatures and the higher the maximum temperatures in the country or year in question, the lower the well-being (Rehdanz and Maddison 2005). In a later study, the authors showed that climate is the second most important explanatory factor for differences in subjective well-being between countries, after per capita income (Maddison and Rehdanz 2020). They also emphasize that these are only direct effects on well-being, since possible influences on income are not included in the analysis (Maddison and Rehdanz 2011). Possible indirect effects due to changes in income (e.g. changes in harvest quantities) can amplify the direct effects.

2.3 Well-Being and Extreme Events

As a result of climate change, extreme events such as droughts, storms and floods are expected to become more frequent and more severe. With regard to droughts, a case study for Australia found significant effects on the subjective well-being of the population in rural areas (Carroll et al. 2009). The correlations found imply that the decrease in satisfaction from the projected doubling of the annual frequency of droughts in the future corresponds to the effect of a one-percent decrease in annual national income. The well-being loss from droughts was found to involve considerable psychological effects in addition to drought-related losses in income. Impairments in life satisfaction due to drought have not only been found in Western “modern” societies, but also for traditional communities, for example in Papua New Guinea (Lohmann et al. 2019).

Other studies have looked at the impact of storms and flooding on life satisfaction. In a study for Germany, storm and hail events as well as floods were found to have a negative impact on life satisfaction (von Möllenorff and Hirschfeld 2016). Furthermore, while the impact of storms and hail proved short-lived, satisfaction took several months to return to previous levels after a flood. A study for the United States matched thirty-one billion-dollar disasters with individual survey data for more than 1.7 million people to estimate the effect of extreme weather events on the subjective well-being of US residents. The results indicate that natural disasters have a negative and robust impact on subjective well-being in the affected communities, and that, on average, this impact peaks 6 months after the event, and then decays over time. Effects are large and significant for severe storm and drought, but insignificant for tropical cyclones. The study finds an attenuating impact of health care access, flood insurance, and governmental assistance programs as well as of stronger emotional and social support (Ahmadiani and Ferreira 2021).

2.4 Well-Being and Environmental Amenities

A growing body of research has studied the relationship between people's subjective well-being and environmental amenities near their place of residence. Differences in environmental amenities were found to explain considerable fractions of the spatial variation in subjective well-being within countries. With respect to Ireland, for example, an early study found location-specific environmental amenities to have a direct impact on well-being (Brereton et al. 2008). Similarly, a recent study for the US found that average subjective well-being is higher in those counties that have more recreational land while being lower in counties with a higher percentage of urban area and those classified as a metropolitan area (Ahmadiani and Ferreira 2019).

At a continental level, a large-scale study related subjective well-being scores and socio-economic data of more than 26,000 European citizens from 26 countries with data on the regional level for species diversity and other nature characteristics. Species diversity was measured as the species richness of birds, mammals (including megafauna) and trees. In addition, indicators were used for other nature and climate characteristics such as landscape and topographic heterogeneity, the area of green and blue space, and protected land cover. The study found that bird species richness is positively and strongly associated with subjective well-being across Europe. Possible pathways for this relationship may be the direct multisensory experience of birds, and beneficial landscape properties which promote both bird diversity and people's well-being (Methorst et al. 2021).

2.5 Well-Being and Land Use

While proximity and access to natural environments go with greater well-being, having so-called locally undesired land uses near one's place of residence goes with less well-being. This applies to living downwind from fossil-fueled power stations, unless they are equipped with scrubbers (Luechinger 2009), the mining, stockpiling and washing of coal (Li et al. 2017), and horizontal oil and gas drilling using chemicals – so-called fracking (Maguire and Winters 2017). Well-being is also negatively related to proximity to nuclear power stations, reflecting perceptions of nuclear risk (Welsch and Biermann 2016), wind turbines, due to visual impairments (Krekel and Zerrahn 2017, von Möllendorff and Welsch 2017), and power generation from biomass, due to odor, but not to solar plants (von Möllendorff and Welsch 2017). In contrast to the effects of biomass plants, those of wind turbines were found to be transitory, vanishing after five years at the latest. There are thus different degrees of adaptation to different types of energy facilities, a finding which may well be relevant for policy appraisal when it comes to the deployment of renewable energies.

2.6 Well-Being and Future Environmental Conditions

The SWB-environment literature includes some scattered pieces of evidence on whether SWB scores capture latent threats and future environmental conditions. Rehdanz et al. (2015) did not find an effect of nuclear radiation on SWB shortly after the Fukushima Dai-ichi nuclear disaster in 2011. They argue that the lack of an SWB effect arises because low-level radiation has no short-term effects on health. By contrast, Danzer and Danzer (2016) found even subclinical nuclear radiation doses from the Chernobyl nuclear meltdown in 1986 to affect measures of SWB twenty years later. Together, these works seem to suggest that SWB captures effects of an event (present or past) at the time when the effects are actually experienced, but may not capture future effects or circumstances. In a similar vein, Qasim and Grimes (2021) found investments into environmental sustainability to be associated with *reductions* in SWB over the next decade (due to negative economic side-effects), but an increase in SWB over the subsequent decade when the benefits from those investments manifested themselves.

In contrast to a lack of SWB effects of future environmental conditions, however, Bartolini and Sarracino (2018) found people's SWB to respond to broad alternative scenarios of the future in terms of whether they expected a "bright" or "bleak" future for humanity. This suggests that expectations about the future do affect SWB. Schmidt et al. (2018) found that perceived ecological threat negatively predicted SWB. More specifically, van der Linden (2014) found that accurate knowledge of climate change predicted negative affect (a component of SWB). These works suggest that SWB may capture adverse future conditions if people expect them to happen and perceive them as a threat.

2.7 Research Question

The literature reviewed provides robust evidence that SWB responds to several dimensions of environmental characteristics that are tangible, that is, actually perceived or experienced, but it is ambiguous whether SWB captures less tangible environment-related conditions and events that occur in the future. Since resilience – the ability of an entity to manage a destabilizing shock or rise in pressure – inherently refers to latent threats rather than to actual perceptions and experiences, it is unclear to what extent national SWB scores capture national ecological resilience. This is the research question studied in the remainder of this paper.

3. Methods and Data

3.1 National Well-Being Scores

The national well-being scores used in this paper are taken from the World Happiness Report 2023 (Helliwell et al. 2023). They represent life evaluations for each country, averaged over the years 2000-2022. The source of data is the Gallup World Poll, a globally representative social survey conducted in more than 160 countries that includes 99 percent of the world's adult population. It asks respondents (among many other items) to evaluate their current life as a whole using the image of a ladder, with the best possible life for them as a 10 and worst possible as a 0. Each respondent provides a numerical response on this scale, referred to as the Cantril ladder. Typically, around 1,000 responses are gathered annually for each country. Weights are used to construct population-representative national averages for each year in each country. The national well-being scores reported in the World Happiness Report 2023 are based on the three-year average, 2000-2022, of these life evaluations (Helliwell et al. 2023, Box 2.1). The range of the national well-being scores is 1.859 (Afghanistan) to 7.804 (Finland).

3.2 State Resilience Index

The State Resilience Index (SRI) defines state resilience as "the extent to which a country can anticipate, manage, and recover from a crisis, relative to the severity of that crisis" (Haken 2022). In that understanding, State Resilience is not just the inverse of State Fragility, a measure that refers to countries' exposure to pressures and shocks but does not measure their ability to cope with these. The SRI is guided by the idea that for resilience, it is not enough to build economic, social and political infrastructures. Rather, "…for resilience, these must be developed in a way that does not create dependency on a single commodity export, a single trading partner, a single authority figure, a single energy source, a single monocrop, or single industry. Because if a shock strikes that single point of failure, then crisis can cascade across the entire system, perhaps even leading to collapse. By contrast, if a country is resilient, it will certainly experience a crisis at some point, but the intensity will be dampened. The effects will be contained. And the country will quickly recover after the crisis has passed." (Haken 2022, p. 9).

The SRI measures state resilience in terms of seven so-called pillars: Inclusion, Social Cohesion, State Capacity, Individual Capabilities, Environment and Ecology, Economy, and Civic Space. Each pillar comprises three to eight sub-pillars. The meaning and contents of the pillars can be gauged from the respective sub-pillars, as shown in Table 1. For example, the Environment-

Ecology pillar is composed of the sub-pillars Pollution, Ocean and Fisheries Health (if applicable), Agricultural Productivity, Ecosystem Health, Biodiversity, Long-term Climate Stability, Clean Energy, and Freshwater Availability.[3]

Table 1: Structure of the State Resilience Index

Pillars	**Sub-pillars**
Inclusion	Inclusion of Youth, Political Inclusion, Access to Finance, Group-based Inclusion, Access to Economic Resources, Access to Employment, Protection Against Precariarity
Social Cohesion	Social Capital, Social Relations, Confidence in National Institutions
State Capacity	Finances, Government Effectiveness, Disaster Risk Reduction, Public Health, Education Outcomes, Rule of Law, Freedom from Corruption
Individual Capabilities	Food/Nutrition, Education System, Health, Wealth
Environment and Ecology	Pollution, Ocean and Fisheries Health, Agricultural Productivity, Ecosystem Health, Biodiversity, Long-term Climate Stability, Clean Energy, Freshwater Availability.
Economy	Diversification, Business Environment, Dynamism/Innovation, Physical Infrastructure, Capital Flows, Economic Management
Civic Space	Engagement, Accountability, Democratic Structures, Human Rights and Civil Liberties, Information Access

Source: Fund for Peace (2022)

The index values on each level (sub-pillars, pillars, total SRI score) are calibrated to vary within the range 1-10. The total SRI score is the average of the pillar scores, which in turn are averages of the respective sub-pillar scores. The data underlying the SRI refer to 2018-2020. The lowest value of the total SRI score is 2.9 (Yemen and South Sudan) and the highest value is 8.4 (Norway).

The focus of this paper is on the Environment-Ecology pillar. This pillar aims to help determine a country's ability to absorb, adapt, and transform in the face of an environmental crisis by measuring *environmental health* (the health of air, aquatic, and terrestrial environments),

[3] In view of the results presented below it deserves to be noted that some economic characteristics of countries (Access to Economic Resources, Access to Employment, Protection against Precariarity) are included in the Inclusion rather than the Economy pillar. Similarly, Wealth is included in the pillar Individual Capabilities. As seen in Table 1, the Economy pillar mainly focuses on the business sector rather than the consumer/worker sector of the economy.

ecosystem vitality (the ecological vitality of local ecosystems and biodiversity), and the stability of the local climate (Sample 2022).

Each country in the SRI has an established Environment-Ecology score, based on the sub-pillars already mentioned, which are themselves made up of a total of 27 metrics collected from several sources (see Appendix A). Within the set of metrics, 14 come from the Yale Environmental Performance Index (EPI) 2020, which indicates to what extent countries are addressing the array of environmental challenges that every nation faces (Wendling et al. 2020).

The differentiation in the Environment-Ecology pillar between *environmental health* and *ecosystem vitality* corresponds to the classification of issue categories in the EPI. As asserted in the EPI, issues under the umbrella of environmental health, as building the necessary infrastructure to provide clean drinking water and sanitation, reduce ambient air pollution, control hazardous waste, and respond to public health crises yields large returns for human well-being (Wendling et al. 2020). In contrast to the environmental health issues, the immediate relevance for well-being of issues falling into the category of ecosystem vitality is less clear as they are of a more intangible, less salient nature.

3.3 Sample Characteristics

The dataset used in this paper comprises 124 countries for which national well-being scores and state resilience scores are jointly available. The summary statistics are displayed in Table B1 in Appendix B. National well-being (life evaluation on the 0-10 scale) varies between 1.86 and 7.80, with mean value and standard deviation being 5.54 and 1.13, respectively. The total SRI score varies between 3.34 and 8.39, with mean value and standard deviation being 5.92 and 1.17, respectively. The Environment-Ecology pillar varies between 3.56 and 7.19; the mean value and standard deviation are 5.31 and 0.86, respectively. The mean Environment-Ecology resilience score is thus lower than the mean overall resilience score, and in fact is the second lowest of all pillars.

The mean values of the Environment-Ecology sub-pillars vary between 3.75 (Agricultural Productivity) and 6.77 (Biodiversity). Some of the ranges of the sub-pillar values are quite large, with minimum values as low as 1.0 (Biodiversity, Clean Energy, and Freshwater Availability).

4. Results and Discussion

4.1 Pillars of State Resilience

Table 2 presents the results from ordinary least squares ((OLS) regressions of national well-being on the total SRI score and the SRI pillars. In a bivariate regression (Column 1), the total SRI score attracts a significantly positive coefficient (0.776), and the explanatory power (proportion of variance explained) is quite high (Adjusted R^2 = 0.649). Column 2 shows the results of a bivariate regression on the Environment-Ecology pillar. The coefficient is significantly positive (0.658) and the Adjusted R^2 amounts to 0.250. Column 3 reports a multivariate regression in which national well-being is regressed on the Environment-Ecology pillar along with the other pillars of the state resilience index. This leads to a considerably lower coefficient on the Environment-Ecology pillar (0.261), but the coefficient continues to be highly significant (at the 1-percent level).

Table 2: Regression Results for SRI Pillars

	((1)	((2)	(3)
Total SRI Score	0.776*** (15.12)		
Environment and Ecology		0.658*** (6.48)	0.261*** (3.13)
Inclusion			0.244** (2.04)
Social Cohesion			0.070 (1.22)
State Capacity			-0.054 (0.39)
Individual Capabilities			0.259*** (3.74)
Economy			0.127 ((1.07)
Civic Space			-0.080 (1.40)
Constant	0.949	2.050	0.713
Observations	124	124	124
Adjusted R^2	0.649	0.250	0.697

Note: OLS estimates; t-statistics in parentheses. * p<0.1, ** p <0.05, *** p < 0.01.

With respect to the other pillars, only Inclusion and Individual Capabilities attract significant coefficients (of a similar magnitude as Environment-Ecology). Perhaps surprisingly, the Economy pillar is insignificant. As noted in footnote 3, however, important economic issues (Access to Economic Resources, Access to Employment, Protection against Precariarity) are not included in the Economy pillar but in the Inclusion pillar whereas Wealth is included in the Individual Capabilities pillar, both of which are significant. In addition, countries' Agricultural Productivity, included in the Environment-Ecology pillar, has economic aspects (as a source of food supply and income) and (as shown below) is significantly positively related to national well-being. Resilience in terms of important economic issues is thus significantly associated with greater national well-being.

4.2 Environment-Ecology Sub-Pillars

Table 3 presents the regression results for the sub-pillars of the Environment-Ecology pillar of state resilience. Columns 1 and 2 refer to the complete sample. Since this sample includes landlocked countries, the sub-pillar Ocean and Fisheries Health is omitted. As seen in Column 1, Pollution, Agricultural Productivity, and Freshwater Availability attract significantly positive coefficients (at the 1-percent or 5-percent levels) whereas the coefficients of the other sub-pillars are insignificant. The proportion of variance explained (Adjusted R^2) of this regression is 0.618.

Table 3: Regression Results for Environment-Ecology Sub-Pillars

	(1)	(2)	(3)	(4)
Pollution	0.371*** (12.48)	0.138** (2.04)	0.338*** ((88.55)	0.334*** (8.43)
Agricultural Productivity	0.192** (2.39)	0.124* (1.67)	0.214** (2.09)	0.238** ((2.35)
Ecosystem Health	0.075 ((1.47)	0.054 (1.11)	0.041 (0.74)	0.043 (0.76)
Biodiversity	-0.067 (1.33)	-0.004 (0.08	-0.050 (0.95)	-0.045 (0.85)
Long-term Climate Stability	-0.10 (0.14)	0.014 (0.21	0.071 (0.85)	0.118 (1.58)
Clean Energy	0.002 (0.07)	-0.007 (0.23)	0.024 (0.58)	0.054 (1.58)
Freshwater Availability	0.067 ** (2.12)	0.077** (2.42)	0.046 (1.35)	
Ocean and Fisheries Health			0.085 (1.52)	0.094* (1.67)
Inclusion		0.117 (0.86)		
Social Cohesion		0.089 (1.40)		
State Capacity		0.008 (0.05)		
Individual Capabilities		0.233*** (3.17)		
Economy		0.092 (0.69)		
Civic Space		-0.099 ((1.64)		
Constant	2.567	0.889	1.889	1.587
Observations	124	124	97	97
Adjusted R^2	0.618	0.698	0.627	0.623

Note: OLS estimates; t-statistics in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Column 2 includes the Environment-Ecology sub-pillars while controlling for the SRI pillars other than Environment-Ecology. The coefficients of Pollution, Agricultural Productivity, and Freshwater Availability continue to be significantly positive. For the former two, the magnitudes and significance (t-statistics) are smaller compared to Column 1. For Freshwater Availability, the magnitude and significance of the coefficient is greater than in Column 1.

Columns 3 and 4, which refer to the sub-sample without landlocked countries, include the sub-pillar Ocean and Fisheries Health. The results in Column 3 corroborate those in Colum 1 that Pollution and Agricultural Productivity are significant, and the magnitudes of the corresponding coefficients are similar to those in Column 1. However, Freshwater Availability is now insignificant, as is Ocean and Fisheries Health.

To see whether this insignificance is due to the simultaneous inclusion of the two variables, Column 4 omits Freshwater Availability. As seen, Ocean and Fisheries Health now becomes marginally significant. The results for Pollution and for Agricultural Productivity are the same as before.

4.3 Discussion

Analysis of data for 124 nations has shown that the Environment-Ecology dimension of state resilience is positively and significantly related to nations' subjective well-being scores, that is, the average life evaluation of their citizens. This is consistent with research conducted over the past two decades that found a positive relationship between individuals' subjective well-being and a large array of environmental quality measures (Section 2).

With respect to the sub-pillars of nations' ecological resilience, Pollution, Agricultural Productivity and Freshwater Availability were found to be statistically significantly related to subjective well-being. Importantly, this finding is robust to controlling for a comprehensive set of potential confounders in terms of the non-environmental (that is, economic, social, cultural, and institutional) dimensions of state resilience. Ecosystem Health, Biodiversity, Long-Term Climate Stability, and Clean Energy were not found to be significantly related to nations' well-being.

Regarding quantitative significance, standardized coefficients suggest that improvements in Pollution, Agricultural Productivity and Freshwater Availability by one standard deviation are associated with an increase in well-being by 0.28, 0.10 and 0.30 standard deviations, respectively. For the overall Environment-Ecology pillar, the standardized coefficient is 0.20.[4]

The empirical results obtained can be interpreted in the light of the research question stated above – whether SWB solely responds to tangible environmental characteristics, that is,

[4] The standardized coefficients are computed from the unstandardized coefficients reported in Column 3 of Table 2 and Column 2 of Table 3, respectively, along with the standard deviations shown in Table B2. In terms of the classification proposed by Cohen (1988), these 'effect sizes" are small to medium sized. In the specification without the non-environmental controls (Column 2 of Table 2), the effect size is 0.50.

characteristics actually perceived or experienced, or captures less tangible environment-related conditions and events anticipated to occur in the future. The Environment-Ecology sub-pillars that were found to be significantly related to SWB – Pollution, Agricultural Productivity and Freshwater Availability – fall into the category of environmental characteristics perceived and/or experienced by individuals. Ocean and Fisheries Health (found marginally significant in one specification) are also perceived by individuals, even if indirectly – as fishery is a source of food supply and/or income.

As noted above, the SRI conceives of the sub-pillars Pollution, Agricultural Productivity and Freshwater Availability as measures of nations' *environmental health*. By contrast, sub-pillars not found to be significantly related to SWB – Ecosystem Health, Biodiversity and Long-Term Climate Stability – are measures of *ecosystem vitality* that are more complex and less tangible (more difficult for individuals to perceive).[5] The share of Clean Energy is also not directly perceived, but a higher Clean Energy share may nevertheless impact SWB through lower levels of pollution associated with it. It is, however, found to be insignificant because pollution is controlled for in the respective regressions.[6]

The empirical results thus suggest that nations' SWB scores capture the tangible but not the less tangible dimensions of ecological state resilience. Arguably, the less tangible measures such as Ecosystem Health, Biodiversity and Long-Term Climate Stability refer to complex phenomena that may partly go unperceived by individuals. In addition, the bulk of effects that follow from their deterioration will occur in the future rather than at present. The result that well-being scores do not capture resilience with respect to those measures is consistent with earlier findings that SWB does not respond to the latent threat posed by low-level nuclear radiation (Rehdanz et al. 2015); however that radiation does impact SWB once its effects manifest themselves (Danzer and Danzer 2016). For national SWB scores to capture environmental conditions whose effects have not yet (fully) materialized, there must be at least a perception of threats related to those conditions (Bartolini and Sarracino 2018, Schmitt et al. 2018, Van der Linden 2014). Such a perception does not seem to be

[5] See Appendix A for the metrics involved. For example, Biodiversity is measured in terms of complex multi-dimensional constructs (Species Habitat Index, Species Protection Index and Biodiversity Habitat Index). In contrast to such composite indices, specific, more easily perceptible dimensions of biodiversity, such as bird richness, are significant predictors of SWB (see subsection 2.4).

[6] Welsch and Biermann (2014) found that a larger share of solar and wind power in a country's electricity mix relative to the share of coal is associated with significantly higher SWB when air pollution is uncontrolled while becoming insignificant when air pollution is controlled for. In addition, the persistent negative SWB effect of biomass plants discussed in subsection 2.5 may countervail the positive effect of renewables in terms of air pollution and may contribute to the insignificance of the Clean Energy sub-pillar.

widespread enough with respect to Ecosystem Health, Biodiversity and Long-Term Climate Stability.

5. Conclusion

Motivated by a recent trend to use subjective well-being as a measure of national performance and social welfare, this paper has studied if and how the Environment-Ecology pillar of State Resilience contributes to nations' subjective well-being. Consistent with previous research on subjective well-being and the environment, it was found that nations' well-being is significantly related to their ecological resilience and that the latter explains a considerable portion of the between-country variation of well-being. However, remarkable differences were found between the various sub-pillars of ecological resilience. While tangible measures of *environmental health* significantly predict national well-being, the less tangible measures of *ecosystem vitality* were not found to be significant predictors of well-being.

Put differently, national well-being scores capture the tangible aspects of ecological resilience – manifest environmental characteristics – but not its less tangible ones – latent ecological threats. Since a nation's ability to manage the latter – in particular threats to Ecosystem Health, Biodiversity, and Long-Term Climate Stability – is increasingly recognized as an essential dimension of national performance, national well-being scores need to be complemented by more forward-looking measures of resilience to latent ecological threats to provide a more encompassing assessment of national performance.

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Appendix A: Metrics and Data Sources of the SRI Environment-Ecology Sub-Pillars

Pollution				
Air Quality	Wastewater Treatment	Heavy Metals	Waste Management	Pollution Emissions
Yale Environmental Performance Index (2020)	Yale Environmental Performance Index (2020)	Yale Environmental Performance Index (2020)	Yale Environmental Performance Index (2020)	Yale Environmental Performance Index (2020)

Agricultural Productivity		
Crop Production Index	Livestock Production Index	Arable Land (hectares per person)
World Bank (AG.PRD.CROP.XD) (2018)	World Bank (AG.PRD.LVSK.XD) (2018)	World Bank (AG.LND.ARBL.HA.PC) (2018)

Ecosystem Health				
Proportion of Forest Area with a Long-term Management Plan [Percent]	Terrestrial Biome Protection (national)	Terrestrial Biome Protection (global)	Protected Areas Representativeness Index	Ecosystem Services
UN Statistics (Indicator 15.2.1) (2020)	Yale Environmental Performance Index (2020)	Yale Environmental Performance Index (2020)	Yale Environmental Performance Index (2020)	Yale Environmental Performance Index (2020)

Biodiversity		
Species Habitat Index	Species Protection Index	Biodiversity Habitat Index
Yale Environmental Performance Index (2020)	Yale Environmental Performance Index (2020)	Yale Environmental Performance Index (2020)

Long-Term Climate Stability			
Susceptibility to Drought	Temperature (Average 2011 to 2020 - Average 1901 to 1930)	Temperature	Rainfall (Average 2011 to 2020 - Average 1901 to 1930)
INFORM Risk Index (Hazard & Exposure) (2022)	World Bank, Climate Change Knowledge Portal (2020)	Institute for Economics and Peace, Ecological Threat Register (2020)	World Bank, Climate Change Knowledge Portal (2020)

Clean Energy	
Share of electricity production from renewables	Nuclear, renewables and Other (% of Total Energy Consumption) ((Consumption nuclear/total consumption)x100)
Our World in Data (2020)	Energy Information Administration (2019)

Water Availability	
Renewable internal freshwater resources per capita (cubic meters)	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources (%)
World Bank (ER.H2O.INTR.PC) (2017)	UN SDGs (6.4.2) (2018)

Ocean & Fisheries Health		
Fisheries	Marine Protected Areas	Ocean health Index Score
Yale Environmental Performance Index (2020)	Yale Environmental Performance Index (2020)	Ocean Health Index (2021)

Note: In each cell, the first, second, and third line indicates the sub-pillar, the metrics, and the sources, respectively. Source: Provided by Nate Haken (Fund for Peace).

Appendix B: Sample Characteristics

Table B1: Summary Statistics

		Mean	Standard Deviation	Minimum	Maximum
National Well-Being		5.54	1.13	1.86	7.80
Total SRI Score		5.92	1.17	3.34	8.39
SRI pillars	Inclusion	6.17	1.50	2.99	9.22
	Social Cohesion	5.46	1.22	1.72	8.14
	State Capacity	6.07	1.38	2.89	8.85
	Individual Capabilities	6.69	1.80	2.37	9.41
	Environment and Ecology	5.31	0.86	3.56	7.19
	Economy	5.24	1.31	2.83	8.16
	Civic Space	5.92	1.17	2.78	9.47
Environment-Ecology Sub-pillars	Pollution	5.49	2.32	2.2	9.9
	Ocean and Fisheries Health	4.50	1.71	1.7	8.7
	Agricultural Productivity	3.75	0.71	2.0	9.9
	Ecosystem Health	5.63	1.46	2.8	8.1
	Biodiversity	6.77	1.48	1.0	9.4
	Long-term Climate Stability	6.30	1.03	3.6	8.2
	Clean Energy	3.85	2.11	1.0	9.7
	Freshwater Availability	5.88	2.75	1.0	10.0

Source: Computed from data in Fund for Peace (2022).

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