Journal of Physics: Conference Series

PAPER • OPEN ACCESS

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To cite this article: A Lips da Cruz *et al* 2019 *J. Phys.: Conf. Ser.* **1379** 012046

Accelerating the realization of the United Nations Sustainable Development Goals through metrological multi-stakeholder interoperability

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Abstract. The timeline for the fulfilment of the United Nations Sustainable Development Goals (SDG) diverse stakeholder interests can be accelerated many times over by creating incentives and rewards aligning individual and corporate self-interests with the greater good. The SDGs have been criticized for setting out ambitious goals with no accountability or enforcement mechanisms and little in the way of incentives or rewards past recognition for contributing to a better future. There is then an urgent and increasing need for quality assured sustainability and economic measurements capable of efficiently coordinating and aligning decision-making across investors, financial markets and governments, the private and public sectors, and institutions. Metrology is key to making the 17 UN SDGs measureable and manageable collectively by individuals globally, in accordance with the 169 targets. This massive global effort will require aligning metrological unit standards for the sustainability targets with financial values and economic key ratios, legally binding property (material and immaterial) rights, accounting standards, management practices incorporating new performance indicators and new standards in sustainable economic models. Just as the profit motive and individual and corporate priorities worked to create a new middle class over the last 200 years, so might they also be harnessed and channelled to create universally accessible opportunities for new ways of generating both financial and authentic wealth. The bottom line is that we liberate the power of common targets, language, and understanding with sustainable categorical standards to support adaptations to local situations in the context of traceability to universal standards.

1. Sustainability, complexity, and metrology

Today's development problems of humanly, socially, and environmentally just and sustainable relationships are enormously complex. Good intentions that prioritize a focus in a restricted range of domains, or heavy handed approaches autocratically imposing one perspective and excluding others, risk catastrophic imbalances worsening human suffering, social discontent, and environmental degradation. The difficulty of the challenges we face is multiplied by the seeming intractability of the need to simultaneously address:

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a. an array of loosely coupled horizontal relationships across social, economic, financial, legal, administrative, scientific, educational, health care, social service, environmental management, business, etc. ecosystems [1-2];
b. at least three vertical levels of complexity in the communications and information infrastructures of each of these ecosystems, including politics and international relationships [3-5]; and
c. equal compensation, wealth, and capital distribution among diverse groups safeguarding economic and civil society stability and evolution across the globe.

Fortunately, a model for the formation of these ecosystems and their interdependencies exists in a suggestive but problematic and incomplete way within current--but unsustainable--policies and practices [6-8]. Though this model met society's needs at its prior stage of development, today it must shift to accommodate the rapidly changing situation in the 21st century. Our aim is to show how this model can be expanded and developed to support broad scale entrepreneurial innovations advancing the realization of the United Nations Sustainable Development Goals (SDGs) (https://unstats.un.org/sdgs/).

1.1. Expanding the incomplete economic model in a fuller definition of sustainability
Today's unsustainable and incomplete economic practices have repeatedly been described as stemming in large part from a too-exclusive focus on manufactured capital and property, at the expense of the genuine wealth of fulfilled human potential, thriving communities, and environmental quality [9-10]. According to this point of view, capitalism can be seen as an incomplete work in progress. Profits are not associated with value creation. Profits are reaped via a linear process of resource usage and depletion. Income and expenditure reports are not accounting for all aspects and consequences of economic activities, production, and infrastructure. Because they are unmeasured and unmanaged, socially distributed returns on investment are used to justify pushing human, social, and environmental costs off the accounting spreadsheets as externalities. Sustainable alternatives likely to move capitalism toward a more complete expression of its positive potentials focus on including these externalities as accountable entries, also known as material issues, in economic models, finance, investment, and management [9-11].

The fulfilment of these potentials requires the creation of horizontally and vertically complex ecosystems incorporating multi-stakeholder information infrastructures analogous to those already in place for manufactured capital and property. Interoperable sustainability mechanisms hinge on the metrological traceability of scientific units of measurement as the means by which financial, legal, entrepreneurial, etc. self-interests are coordinated to provide returns on investments to individuals and disseminate creative advances for the greater good.

1.2. The roles of measurement science and metrological interoperability
The viability of metrological traceability and standardized units of measurement for human, social, and natural capital has been established in a number of recent works [12-15] rooted in previously validated, experimentally proven models, principles, and results [16-23]. The measurement models involved posit the form of interval units estimated on the basis of minimally sufficient statistics [17, 19, 23]. These models guide experimental tests of the hypothesized unit, the conditional independence of the model parameters, and the substantive meaning of the parameter estimates [18, 20, 22-23]. The results of these tests inform item banking, adaptively tailored instrument administrations, reporting and interpretation [18, 20, 22] throughout networks and ecosystems sharing the common language as the medium of coordinated decision making [12-13, 22, 24-27].

The key point at issue is that much of what we want and need to measure exists objectively in ways that can be usefully put to work in sustainability information systems. How to access and leverage this objectivity requires levels of technical expertise not widely available among those most concerned about sustainability. Researchers and managers in multiple fields often assemble groups of indicators carefully devised for the purpose of systematically observing pollution, or literacy, or health, or the prevalence of armed violence. But they then do not follow through to evaluating when, where, and how they have obtained objective evidence, and they cannot then use that evidence to achieve their ostensible goal of measuring the object of interest.

Instead, first, they report results for each indicator separately in a nonlinear ordinal unit, when they should have combined the observations across indicators in a model of the higher order construct that would meaningfully annotate a continuum of less to more scaled in a linear interval unit. Second, different groups assembling different indicators supposedly measuring the same thing do not work together to define a common language by equating their scales to a shared metric with known uncertainties. This project aims to lead the way toward fulfilling the intention to measure sustainable developments in way that inform effective sustainability management and communications.

2. The UN SDGs

The United Nations Resolution 70/1 “Transforming Our World: the 2030 Agenda for Sustainable Development” was unanimously adopted by the General Assembly in 2015. This 2030 Agenda, as it is known, sets out 17 Sustainability Development Goals (SDGs) in a comprehensive plan for sustainable prosperity, involving all people and the planet as a whole.

2.1. Shortcomings of typical approaches to sustainability metrics

With only very rare exceptions [26], efforts to date at quantifying progress toward the SDGs do not match their comprehensive scope with a similarly comprehensive measurement science. Numeric counts of events and sums of ratings are assumed to be, but actually are not, quantitative measures in the scientific sense of the term [12-27]. In addition, valid scientific units of measurement, such as tonnes of effluent, cubic meters of emissions, kilowatt hours, etc., do not, in and of themselves, stand as quantitative evidence of less and more sustainability. The status of these units for their intended use in quantifying physical amounts does not automatically translate into quantification of a separate domain of a new social construct not included in the conceptualization of the original purpose of measurement.

Finally, sustainability impact metric standards are commonly assumed to depend on consensus agreements regarding shared indicator or target content, where the same events are counted in the same numeric terms. These kinds of standards are insufficient for at least two reasons. First, the counting units literally do not add up. The size of the unit changes depending on the local specifics of what is counted. In the same way that sometimes three, and other times six, oranges will weight two kg, so, too, not all instances of literacy, health, or armed violence are created equal.

The second reason why consensus content standards are insufficient to sustainability measurement is that they narrowly restrict the definition of what counts as sustainability to the specific terms of the chosen indicators. A functional model of any measured construct, from literacy to health to poverty reduction, must feature an open architecture capable of encompassing any instance of the phenomenon of interest. It must be possible to add new indicators as they become relevant, and to drop old ones as they become irrelevant. Complaints about existing accountability systems often focus on how reporting impacts in the specific terms of a limited set of indicators fails to give credit where it is due, and moreover detracts from pursuit of the larger mission.

In short, sustainability needs to be modelled, estimated, calibrated, theoretically explained, and systematically measured at a given level of precision, with known uncertainties, in a standard unit. Until measurement of that quality is obtained, sustainability communications and efforts will be severely hampered by the lack of a common language capable of supporting a new economic system of sustainability incentives and rewards.

2.2. Reconceiving sustainability metrics in terms of measurement science

A science of experimental evaluations of evidence, calibrated instrumentation, and predictive theory is a technical undertaking that will require considerable investments of resources to create. Our purpose is to alert those interested as to the viability, feasibility, and desirability of a sustainability measurement science and associated metrology.

Journal of Physics: Conference Series **1379** (2019) 012046 doi:10.1088/1742-6596/1379/1/012046

Mapping impact measurement in support of the 17 SDGs then means abandoning the usual approach to sustainability metrics, where every indicator is treated as a separate universe, a silo, scaled in its own ordinal ranking "metric". In the new art and science of sustainability measurement, we take into account the interdependencies among the different SDGs (Figure 1). We know how all of our indicators work together to provide coherent, consolidated measures, and we know what data-based and theoretical consistencies make sense. Sustainable development occurs in broadly predictable sequences, in much the same way individual, organizational, social, and economic patterns of development unfold.

We identify capitalisation opportunities relevant to the SDGs, reallocating capital resources and mapping the world of sustainability to enable navigation towards the targets specified by the UN.

Figure 1. The 17 United Nations Sustainability Development Goals.

We focus here on describing how our approach to the SDGs aligns finance with environmental, social and governance considerations in ways analogous to existing alignments of finance with manufactured technology. Via these new alignments, individuals, companies, and countries will be able to increase their valuations and trustworthiness simultaneously, empowering themselves in market comparisons, with their brilliant solutions, their courage, and their empathic efforts. A new perspective, concept, and array of tools set the stage for transformations fulfilling the lofty mission of the 17 SDGs targets and beyond, financing sustainability and solutions for humanity, and indeed for all life on planet Earth.

Our methods are based on financial, economic, and sustainability data measurement metrics that (a) evaluate companies' and countries' data; (b) calibrate scientific instruments measuring in meaningful and objective interval units capable of serving as common measures for economic and sustainability value; and (c) enhance efficiency in essential ways by means of predictive, stochastic models. These mathematical models, unit definitions, and calibrated instruments form the basis of a new consolidated standard in the market.

We create a space enabling different stakeholders to work together, cooperatively competing to build on the best in the world, evaluating and rewarding comprehensive sustainability efforts. The knowledge technologies we deploy enable investors, credit granters, managers, customers, employees, and communities to systematically and collectively nudge companies and countries, leaders and steering boards, to work towards lasting realizations in sustainable growth.

Our methods facilitate the visualization of sustainability risks and opportunities by dramatically reducing data volume with no loss of information for each company or country in its comparisons in the markets. Results are expressed in a common interval metric across and within countries, companies, and sectors by region. All metrics are annotated with qualitative information, and every individual measure is always given along with its associated range of risk and uncertainty. The best part is our automated unique Finder tool, which identifies special risks and opportunities impacting investment decisions.

2.3. A three-stage plan for near term products

Over the course of the next two years, we will develop and deploy in three stages an online platform for complementary investment and management knowledge technologies supporting realization of the UN's 17 Sustainability Development Goals, 169 targets, and 233 official indicators (nine indicators are repeated in two or three different targets, making for 244 indicators in total).[2] We will initially focus on SDG 4 on Education, SDG 13 on Climate Action, SDG 16 on peaceful, inclusive, and just societies and institutions, and SDG 17 on sustainability partnerships. Our work will itself be an instance of SDG 9 on innovation and infrastructure where equality and diversity are key factors.

The three stages initially focus on investor and credit risk guidance, proceed from there to management quality improvement applications, and finally shift from company-level measures to individual-level measures. Each stage will begin with the identification and leveraging of existing high-quality scientific metrics and linear measures where these exist [24-26]. Existing ordinal data sources are being evaluated for their measurement potential. For instance, an extensive study has already been made of the Carbon Disclosure Project's (https://data.cdp.net/) data on regulatory, physical, and other risks and opportunities due to climate change. Other SDG data on armed violence reduction, freedom of the press, and other areas have also already been analyzed and evaluated. These efforts will be followed by working as needed to develop new linear measures that hew as closely as possible to the content of the SDG targets, making them freely available online for others to use in the national and regional efforts.

Our products will integrate data with calibrated instrumentation and predictive theory in an advanced approach to modelling bottom-up flows of self-organizing information. The principles of complex adaptive systems are put to practical use in creating useful tools communicating meaningful and actionable results to end users, with no need for time-consuming intermediate analyses and reporting. The mathematical models to be used have long-standing, established histories of successful application in a wide range of fields spanning the natural and social sciences. Existing software tools available to provide platforms for development are appropriately designed to support multiple stakeholder ecosystems [27]. End products will include scientifically calibrated metrics for each measurable SDG construct, investment and management interpretation guidelines for each metric, defined unit standards, APIs for third party online applications, etc.

3. Concluding comments

Currently in the market the usual approach to scoring sustainability indicators is separated from the financial aspects, resulting in numbers that do not add up and consolidate in a meaningful quantitative way. Ratings and scores are ordinal, meaning that they vary across different assessment schemes, and are locally useful for ranking companies and countries, but not for saying how much more or less sustainable one company's or country's policies, practices and solutions are than another's.

Decades of established research demonstrates alternative scaling methods supporting linear interval units of measurement that retain uniform meaning across different indicators, and that routinely include risk and uncertainty estimates. This quantitative information possesses a qualitative meaningfulness and scientific rigor as yet unknown to our competition. Real value lies in providing easy and universal access to meaningful uniform metrics and quantitative comparisons; this will be a primary focus going forward. But the qualitative results revealed by our strategic methods are where small local inefficiencies and a new class of sustainability investment risks and opportunities are identified. Sometimes companies and

[2] https://sustainabledevelopment.un.org/content/documents/11803Official-List-of-Proposed-SDG-Indicators.pdf

countries have special strengths or weaknesses that leaders, owners, managers, and investors could capitalize on, if only they knew about them.

The success of this project will focus attention on the need for a new institutional economics of human, social, and natural capital. This concerns the rules, roles, and responsibilities needed for establishing efficient markets [28-29]. Of particular importance will be the ways in which scientific metrology calibrates standardized instruments capable of mediating capital budgeting decisions via industry-wide consensus on common product definitions and legal title to shares of human, social, and natural capital stocks.

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