Cover design by Nancy Gelband O'Connor

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New Voices for the New Challenges

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Founder, *Journal of Environmental Investing*

When we started the *JEI* ten years ago, this issue's contributors had likely not come to their investigation of environmental investing.

After a one-year hiatus, we're back, and as this issue shows, we're back with groundbreaking research on environmental investing. The content of this 2019 issue reflects how far we have come since our inaugural issue ten years ago . . . and how far we have yet to go. While the science of climate change remains unambiguous in its conclusions and the pathways to mitigation and adaptation become clearer daily, the United States' current grifter president and his co-conspirators respond irrationally. They continue to put forth a series of disjunctive, vindictive edicts that consistently undermine civil society's collective commitment to broadly address the challenges of climate change, encouraging actions and behaviors never conceived of in even the worst business-as-usual scenario. Placing self-interest about common interest and valuing alternative facts over peer-reviewed hard science, they hasten the cataclysm that awaits such ignorance.

Fortunately, a growing number of young scholars and practitioners have emerged and are actively ignoring the U.S. leadership's profligate attitude. In an act of resistance, they are undertaking and sharing serious original scholarship that directly identifies, measures, and mitigates the risks associated with climate change and in so doing are providing investors with knowledge and tools that helps them make better investment decisions. The authors of this issue's essays are certainly among the leaders of their generation.

We're fortunate to have these various voices mediated by our guest editor, Dr. A. Stan Meiberg, Director, Graduate Programs in Sustainability, Wake Forest University. I was introduced to Stan by Jim Dunn, CEO/CIO of Verger Capital Management. Jim and I share a common interest in environmental investing, an interest Jim expresses daily in his own investment portfolios. When Stan joined the Wake Forest University faculty in 2017 after concluding a distinguished 39-year career at the Environmental Protection Agency as Acting Deputy Administrator from 2014 to 2017, Jim arranged for us to meet. It quickly became clear that Stan saw a genuine need to include new, serious voices in the climate discourse and that the *JEI* could serve as the medium for this inclusion. Stan eagerly volunteered to lead this "young scholar" issue.

His leadership was immediately evident when he stated that these new voices would benefit from an independent review of their work, and he arranged to have a recognized investment professional or scholar provide a concise critique of each research paper. We have published these reviews alongside the original essays.

This combination of experience and perspective and the vitality and academic rigor certainly makes this one of our finest issues, an issue that would not have been possible without the continued contribution of our Managing Editor, Mary Cavanagh, who truly makes each issue a reality.

Peace,

Angelo Calvello, PhD
Founder

Millennials and Sustainable Investing

A. Stanley Meiburg, PhD
Guest Editor

Millennials, defined as those born between 1981 and 1996, are entering the years when investing will become a subject of greater and more widespread interest. While as a group, many will still be focusing on securing careers, paying off student debt, raising children, and buying homes. However, some will find themselves inheriting significant resources from their parents and having to make decisions on how to invest this income as part of the estimated transfer of $24 trillion from baby boomers to millennials—the largest transfer of wealth in history (Fink 2019). Some millennials are entering the financial services industry, where one of the key questions will be whether financial portfolios comprising firms that promote sustainability as part of their value proposition can compete effectively for investor attention with more conventional investment products.

There has been a great deal of discussion about whether environmental issues, most notably but not limited to climate change, will be more important as core values to millennials than they are to their boomer parents. Recent data suggests that millennials see themselves this way (Coughlin 2018). At the same time, other surveys suggest that millennials show similar or even less engagement on global climate change than older age cohorts (Kuppa 2018).

For this issue of the *JEI*, we were interested in exploring the concerns of millennial-age students about how Environmental, Social, and Governance (ESG) factors might play into investment decisions by this group. So the *JEI* put out a call for papers seeking student perspectives on environmental investing. The intent was to promote the "voice" of those who will reap the future benefits of such investments (and conversely, suffer the consequences of poor investment choices).

The response to this call suggested several things. The first is that environmental investing (and its related concept, sustainable investing) is a growing but still emerging field for millennials, just as it is for the investment community as a whole. The papers we received covered a wide range of topics: analysis of investment risk posed by water shortages or a changing climate; opportunities for investing in unconventional places (for example, "blue carbon" resources); means for improving estimates of factors such as corporate greenhouse gas (GHG) emissions that may be of concern to socially conscious investors; and identification of which sustainability-related factors are likely to be of greatest relevance in driving investment portfolio risks and returns. All of these topics reflect a heightened awareness of the importance of environmental factors as a context for investment decisions.

That said, the scholarly concerns of those who responded to this call are similar to those of their more senior colleagues. To be sure, aspects of these concerns might not have occurred to earlier analysts—as one commenter noted, the term "blue carbon" is unfamiliar to most of the investment community. Earlier generations were more likely to see environmental protection and economic growth as a zero-sum game; contemporary entrepreneurs see pollution as waste and, especially when a price is placed on what is otherwise an externality, they look for ways to reduce it or turn a former waste product into an input for a new product or service (think, for example, of district heating or combined-cycle gas turbines that generate electricity).

Still, the articles in this collection reflect that issues of cost, price, risk, opportunities, market efficiency, and return on investment are as relevant to millennial writers as they are to earlier generations. This is consistent with principles of sustainability. Economic factors are joined with social and environmental ones in any sustainable enterprise, and all three must be considered together. They are of course separable analytically: for example, economies exist at the sufferance of society, and society exists at the sufferance of the environment. But to state the obvious, absent a subsidy, the most environmentally or socially conscious enterprise cannot exist for long in a market economy unless it at least breaks even, and it cannot attract capital unless it offers competitive rates of return. Government can and does subsidize public investments, of course, whether in the form of direct financial payments or protected markets. But, at least in the United States, strong political ideology has expressed itself in opposition to such subsidies, except where they have benefitted political actors (in which case Miles' Law (1978)—"where you stand depends on where you sit"—applies).

Putting this last case aside, enterprises that promote social and environmental sustainability have to be financially sustainable themselves. The shift in thinking now is that a concern for sustainability can reduce investment risks and enhance potential returns, not that risks and returns are irrelevant to sustainability. The recent letter from Business Roundtable CEOs does not argue that investor returns are irrelevant; it simply expands the range of factors considered as risks and returns to include social and environmental attributes, And it argues that investors should consider customer value, investing in employees, ethics in supplier dealings, and support for communities and the environment, while still "generating long-term value for shareholders" (Business Roundtable 2019).

ESG investing remains a specialized topic in the larger investment community, though interest is growing. According to Ceres, a well-established nonprofit organization that promotes sustainability considerations in investing, its Investor Network now includes over 170 institutional investors that manage more than $26 trillion in assets (Ceres 2019). In 2018, Larry Fink, the Chief Executive of BlackRock, an investment firm with over $6.5 trillion in assets, notably called for executives and boards of companies to "understand the societal impact of your business." Moody's Corporation, a credit ratings agency, recently purchased a majority stake in Four Twenty-Seven, a California company that measures signals of climate change. A Moody's spokesperson indicated that this purchase was important to the company in assessing climate-risk exposures of companies, stating, "You can't mitigate what you can't understand" (Flavelle 2019).

Despite their diverse topics, common interests emerge in the five papers included in this edition of the *JEI*. One concern of all the authors is how to frame a comparison of the financial risks and opportunities of sustainable investing with the more traditional measures of investment performance. For example, Ryan Cook's paper on "blue carbon" and Jens Christiansen and Marleen Schutter's paper on the "blue economy" both tackle this question: How do you develop metrics that are capable of convincing investors that there are opportunities (and risks) in these areas? The Zsolt Simon and Chiara Legnazzi paper on tail risk mitigation offers one approach for enabling investors to judge which companies pose material investment risks based on factors not usually captured in traditional indicators. A similar question presents itself in Mette Kjaer's paper on estimation of greenhouse gases, where the underlying assumption is that investors will care about what a company's greenhouse gas exposure will be. Professor Erhardt's comment on the methodological challenges of such calculations reinforces the underlying point: If such metrics matter to investors, they will need trusted, timely, and accurate indices that frame risks and opportunities in understandable ways.

This leads to a second point. Some of our authors appear to be asking the private investment community to take on the job of solving basic social problems. Even putting aside the overwhelming challenge of a changing climate, it is hard to imagine an investor of twenty years ago being asked to frame investment decisions around questions of how to sustainably finance and manage our oceans (Christiansen and Schutter), or make capital investments in the capacity of the oceans to absorb carbon dioxide from the atmosphere (Cook). Historically, both of these policy areas would have been seen as the province of governments and handled through command and control regulations that are more traditional. The fact that our authors are putting forward investment mechanisms as means of addressing ecological dilemmas may represent a recognition either of the power of markets and investment to affect change or of the weakness (or perhaps mistrust) of contemporary governments' ability to tackle such problems. Or perhaps both.

A third common theme is the writers' focus on the importance of systems thinking in making investment decisions. Examples of this include risks to sectors dependent on systems for both potable water and the water supply for industrial purposes (Bokern), and the importance of coastal and estuarine ecosystems not just for fisheries habitat but also as integral parts of terrestrial mechanisms for carbon sequestration (Cook). This systems-thinking approach represents an admirable advance over an investment perspective that limited the obligations of corporate responsibility to their obligations to shareholders, thereby incentivizing companies to displace costs (in effect, maximize externalities) to the extent allowed by law. That said, it remains a challenge to make complex human and ecological systems understandable, and to creating appropriate boundary conditions to allow systems to be described usefully to investors. Seeing everything as related to everything else may be true, but it is not useful for investment decisions, which inevitably, even at their best, rely on "bounded rationality," a term usually associated with, though not precisely coined by, James March and Herbert Simon (March and Simon 1958; Weick 2017).

Beyond the awareness of financial risks and opportunities, a fourth theme of the articles is how to promote accountability and transparency in how firms conduct their operations. While this theme is most evident in the Kjaer article, it underlies the others as well—a recognition that for many millennials, sustainability concerns are not merely instrumental values but intrinsic ones. This desire for accountability and transparency has now become mainstream. The Global Reporting Initiative (GRI) notes that thousands of firms across the globe have published reports using GRI's sustainability guidelines, and that other organizations, including the Organization for Economic Cooperation and Development (OECD), the United Nations Global Compact (UNGC), and the International Organization for Standardization (ISO), have also published guidance on sustainability reporting (GRI 2019). This demand for accountability and sustainability appears to have become the new normal for corporations. In a recent survey, Jill D'Aquila, citing data from the Governance and Accountability Institute, reports that about 81% of the companies in the Standard and Poor's 500 stock index issued sustainability reports in 2015, as compared to less than 20% in 2011. Over 13,000 companies produced more than 80,000 reports worldwide in 2016, and a 2017 survey by the accounting firm KPMG found that sustainability reporting has now become "standard practice for large and mid-cap companies worldwide" (D'Aquila 2018).

This highlights a fifth common theme among the articles: It's all about the data. The refinement of data—whether through the development of better indicators as noted previously, the acquisition of new and better data in unconventional areas, or the development of better analytical tools to assess and turn the data into useful information—gives a strong empirical cast to the submissions we received. The articles examine a wide variety of data sources, both public and private, in the search for the best utility. Spoiler alert: There are no perfect answers.

Nevertheless, even though the articles are all about data, we should be mindful of the value sets on display in framing the questions about what data should be collected and analyzed. The articles take as a given that questions of sustainability and the environment are important and worth considering, and not simple instrumental choices. As noted earlier, it is too soon to say whether sustainability and the environment will be an enduring focus of millennials, since these values compete for attention with more mundane concerns. But the infrastructure for transparency and accountability continues to develop and grow more robust. Moreover, evidence from around the world highlights that even authoritarian regimes feel pressure to deal with environmental degradation. The accelerating and present threats posed by a changing climate have mobilized an unusual degree of common global concern, as symbolized by the Paris Accord of 2015 and follow-on actions, such as the Kigali Agreement on the phaseout of hydrofluorocarbons. While some elements of political opinion in the United States still dispute the significance of increasing greenhouse gas concentrations in the atmosphere, the rest of the world has moved past this. For many reasons, knowledge and information by themselves are not enough to produce effective action to mitigate these consequences, but it is impossible not to be aware.

Both the topics addressed and those not addressed in the papers we received suggest areas for future work. One of the most interesting is the question of what truly motivates people to engage in investment practices that promote sustainability. Is it really just an extension of traditional economic incentives, or do other motivations underlie such choices? If, at some level, a forced choice exists between maximizing short-term returns and making more sustainable investment choices, are at least some investors willing to experience lower rates of traditional short-term returns in exchange for nonmonetary benefits, such as improving income distribution patterns in society or protecting ecosystem services? If so, what are the drivers that produce and encourage such behavior?

A second question is what sustainable investing might look like in other sectors of the economy. An obvious target for study is agriculture. Certainly the demand will be there: The United Nations' estimate of the median population by 2050 is 9.5 billion people, and by 2100, 11.0 billion people (UN DESA / Population Division 2019). Food supplies would at least need to continue increasing at current rates. One student argues that food production will need to increase between 25% and 70% above current rates; others posit higher rates if developing countries adopt diets that approach those in the developed world (Hunter 2017). At the same time, these needed increases will be facing headwinds from a changing climate. Just in the United States, the Fourth National Climate Assessment notes that such changes threaten agricultural productivity and create pressures on soil and water resources to support that productivity (USGCRP 2018). These same threats will apply globally, if somewhat differently in different sectors. In addition, pest threats to agricultural productivity are also expected to increase (Deutsch et al. 2018). These risks also pose investment opportunities—for more drought-resistant, heat-tolerant crops or improved farming methods that can increase productivity in the face of adverse climate conditions.

No doubt many other examples for further research can come to mind. It does appear, in the words of one observer, that even though sustainable investing hasn't replaced traditional investing, and many skeptics remain, that "sustainable investing may enter the mainstream faster than expected" and that those "financial institutions not yet compelled into action may soon be pushed into it" (Brown 2018). The interests of these authors in particular aspects of this larger development are heartening. It is my own view that investment and financial incentives are, at the end of the day, no substitute for effective governmental action. But it is heartening to see corporations and investors responding to the world's great need by stepping up and offering clearer visions than seem to be coming from certain governmental sectors. For many years, political scientists and political leaders have struggled with the notion of governments' appropriate role in restraining corporate power. How ironic it is to see the emergence of a dynamic where investors' influence can perhaps push government in directions that are more representative of the common good.

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Biography

Dr. Stan Meiburg became Director of Graduate Studies in Sustainability at Wake Forest University in Winston-Salem, North Carolina, in July 2017, following a 39-year career with the U.S. Environmental Protection Agency. He was EPA's Acting Deputy Administrator from 2014 to 2017, after serving in senior career positions around the country. He was Executive Director of EPA's Environmental Financial Advisory Board from 2001 to 2010, and currently serves as chair of the North Carolina Environmental Management Commission. Dr. Meiburg holds the BA degree from Wake Forest University, and MA and PhD degrees from The Johns Hopkins University.

Water Stress: A Global Risk Analysis for Financial Markets

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Abstract

Water scarcity and droughts are expected to be major problems in future decades. Accordingly, the aim of this paper is to evaluate what is currently possible in order to quantify water scarcity-related risks with the currently available data. The research focuses on the possibilities to determine hazard, exposure, and sensitivity for publicly traded companies on a global scale.

The World Resource Institute's Aqueduct data, the Exiobase input-output table, and the Carbon Delta location database were used to approximate hazard, exposure, and sensitivity of business sectors and individual companies. Although developed damage functions do not allow for an exact quantitative assessment of risks, they demonstrate which companies are most affected by water stress because of both their business model and their facilities' spatial distribution by considering different climate scenarios.

The results indicate that large parts of risk are carried by a few economic sectors, such as agriculture and energy utilities sectors. Differences between sectors are large. Furthermore, socioeconomic developments have a bigger impact than climate while the climate change effects are still measurable in later time steps. The developed metric is capable of dealing with a large number of companies and their assigned locations, potentially enabling investors to compare their portfolio's water risk to reference data like an average risk value. Despite uncertainties arising from input data and methodology, the introduced water-stress model can help investors to reduce their long-term water risk and consider it in their strategic decisions.

Water Stress: A Global Risk Analysis for Financial Markets

For the last four years, "water crisis" has been listed in the "Top Five Risks in Terms of Impact" in the World Economic Forum's Global Risk Report (World Economic Forum 2018) while globally, we have seen a sharp global decrease of available freshwater resources per capita (Ripple et al. 2017). Water availability issues often result from a combination of climate change and population development (Parish et al. 2012). A pioneering study in this field found that population and socioeconomic development might even have a larger impact than changes in climate from 1985 to 2025 (Vorosmarty 2000). In recent years, large institutions picked up this issue and pushed for economic or physical water risk assessments on qualitative and quantitative scales. Some models have been developed to assess water stress or corporate exposure to water stress (Ecolab 2017; Park et al. 2015; PRI 2018; Ridley and Boland 2015; WWF 2018). Yet, none of them can deal with large amounts of input data, which is highly important when investors need to analyze portfolios containing numerous assets. Moreover, systematic global knowledge about the impacts of socioeconomic drought or water scarcity for quantifying risks is still missing. Financial markets need exactly this global view in order to adjust their strategies and contribute to the mitigation of climate change risks (IPCC 2014). The Task Force on Climate-Related Financial Disclosures (TCFD) developed a voluntary framework to reveal the financial impact of climate change on a company level, pointing out the importance of market transparency from the investor's perspective. So, the lack of globally comparable water-scarcity assessments and the need for information on the investor's side, in combination with a missing approach to apply water-scarcity assessment to a large data set, form the research gap for this work.

Methodology

Water risk for a company mainly consists of two factors. First, environmental conditions determine if a company can be hit by water stress. Second, the impact scarcity can have is dependent on the nature of the company's business and its resilience against water stress (Jorisch et al. 2017).

Unlike other natural hazards, water scarcity develops over a long period of time, making it difficult to quantify its damages (Ding, Hayes, and Widhalm 2011). Additionally, water stress often does not cause visible damages, but rather affects profitability, for example, by disrupting supply chains or increasing operating costs (CDP 2017). However, in the short term, drought does not affect production capacities (Freire-González, Decker, and Hall 2017, 198).

Despite all the differences of other hazards, it is still possible to apply a frequently used approach to evaluate environmental risks (Hallegatte 2014) because it combines the natural hazards with business-related factors, and therefore serves as a good approximation for environmental risks to corporations:

$$\text{risk} = \text{hazard} * \text{exposure} * \text{sensitivity} \tag{1}$$

Where hazard is the likelihood of occurrence of an environmental threat; exposure is the value exposed to the hazard and sensitivity is the value lost if the hazard occurs.

Hazard

Water is a crucial resource for businesses and can therefore pose a threat when it is not available in a sufficient amount or quality. A current scientific method for assessing drought and water scarcity is the use of widely applied drought indices, mainly used for agriculture (Vicente-Serrano et al. 2012). Although they are handy to use for agriculture—since many studies report experiences with their application—drought indices do not suit our research goal to measure stress globally throughout all economic sectors. Sectors such as thermoelectric power generation or heavy manufacturing are difficult to assess by using precipitation and evaporation data. Hence, a broader approach is needed: one that covers persistent water stress rather than short-term drought indices that allow evidence only on agriculture-related businesses. While our model is less exact for certain sectors, such as agriculture on the one side, the concept allows a global comparison of sectors, which represents the core goal of this paper.

As this work depends on open source hazard data, accessible data sources that provide a global coverage are limited. We chose the World Resource Institute's Aqueduct maps (WRI 2015), since it offers current stress conditions as well as future projections for three different scenarios (Table 1), plotting potential shared socioeconomic pathways (SSPs) in line with matching representative concentration pathways (RCPs). Projection data is available for the time steps 2020, 2030, and 2040.

Table 1: Different WRI Scenario Ensembles Applied to Raw Data to Assess Climate and Socioeconomic Impact on Water Resources

Number	Climate	Socioeconomic conditions	Interpretation according to WRI
1	RCP4.5	SSP2	"cautiously optimistic" combined with "business-as-usual" socioeconomic conditions; In dataset: "optimistic"

2	RCP8.5	SSP2	"business-as-usual" climate scenario and "business-as-usual" socioeconomic conditions; In dataset: "business as usual"
3	RCP8.5	SSP3	"business-as-usual" climate impact and "pessimistic" socioeconomic conditions; In dataset: "pessimistic"

Source: *Author, 2019.*

Their Baseline Water Stress (BWS) indicator describes persistent water stress on a catchment scale by relating 2010 water withdrawals to the mean of water availability between 2010 and 2050:

$$BWS = \frac{water\ withdrawals\ (2010)}{Ba\ (mean\ 1950, 2010)} \qquad (2)$$

Where: Ba = blue water available.

Projections are computed similarly:

$$BWS_t = \frac{Withdrawals\ (target\ year)}{Ba_{t-10:t+10}} \qquad (3)$$

Exposure

As described previously, water stress mostly causes business interruptions or other revenue-related costs. Hence, analyzing drought means analyzing its effects on a company's revenue. In industrialized countries like the United States, most water withdrawals (86%) are freshwater (USGS 2014). Saline water is nearly irrelevant for business sectors, other than in energy generation, indicating that risk exposure lies in freshwater availability. For a global study like this one, it is inevitable to find a proxy for exposure throughout all business sectors in order to compare them. Therefore, water intensities were selected as a measure for freshwater dependency. They describe how much freshwater is withdrawn per unit of revenue, connecting environmental impact with economic performance.

We used the Exiobase multi-regional environmentally extended supply input-output database that contains water intensity data for 48 countries or regions and 163 industries, accounting for about 90% of the global economy (Stadler, Steen-Olsen, and Wood 2014).

The current Exiobase water database (Stadler et al. 2018, 508) is derived from Food and Agriculture Organization (FAO) data; previous studies for the agricultural sectors (Mekonnen and Hoekstra, 2011; Pfister et al. 2011); and the WaterGAP model (Flörke et al. 2013) for the industrial sectors, which also contributes to some agricultural sectors. The authors chose modeled data since they could not find any satisfying monitored data.

For this study, Exiobase 3 and Exiobase were used for economic information and water analysis (Exiobase 2015). Economic output data was collected from national databases as well as from the UN macroeconomic data set (United Nations 2017). In general, versions 2 and 3 do not differ strongly from each other, but for the most current version, granularity in input sectors, especially for water accounts, was increased. Nevertheless, we used Exiobase 2 for water intensities since our controls and comparisons with reference data showed that Exiobase 2 environmental satellite data is probably the better proxy for our metric due to changed water inputs.

To compute water intensities from Exiobase, the metric aggregates water withdrawal intensities for each of the 163 sectors in 43 countries and in 5 world regions. If aggregation on a sector level leads to zero values, those values were interpreted as data gaps, since they are not specifically marked. A global median over all countries for every sector is the final result of this step.

For reasons of clarity, sectors are aggregated by similar water intensity and business activity. This step was performed by taking the weighted mean of the water intensities of the Exiobase sectors assigned to a new water-risk sector (WRS). Weights are computed using the material flow table “T” and the revenue table “A” of the data set. We follow the approach of the ETH Zurich working group in order to compute sectoral revenues and, eventually, weight water intensities when combined in the new WRS scheme (Droz and Hellweg 2018):

$$A = \frac{i}{R} \tag{4}$$

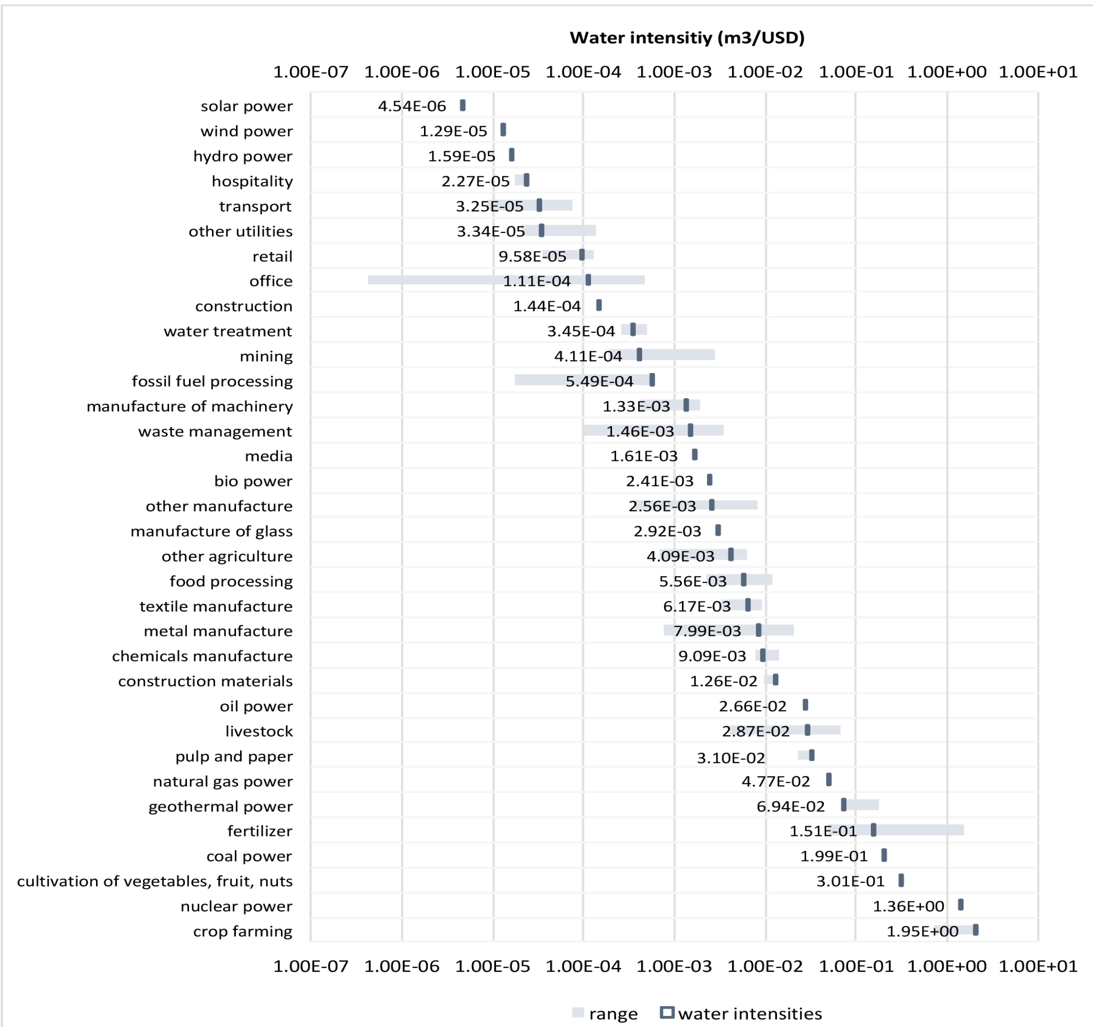
$$R = \frac{V_a}{1 - A} \tag{5}$$

Where: i = purchased input value; R = revenue; V_a = value added

Sectors are manually mapped to the "FactSet Revere Business Industry Classification System" (RBICS) which gives a very granular view of the actual business model (FactSet 2017). The result of this process is 34 water-related economic sectors that are on the one side linked to our water intensities and on the other side linked to financial market data (Figure 1).

Figure 1: Globally Averaged Water Intensities for the 34 Water Risk Sectors

Markers represent water intensities for the sector applied for computing in later steps. Gray bars show the range of values from which the intensity was determined by a weighted average.



Source: *Author, 2019.*

A location database is crucial for our analysis. For this study we used the Carbon Delta locations database that consists of company-reported locations and locations researched via data mining. For every facility at its defined location, it provides an estimate for how much revenue is generated in every sector. This creates the possibility to be able to perform analyses on a location, a sector, and a company level.

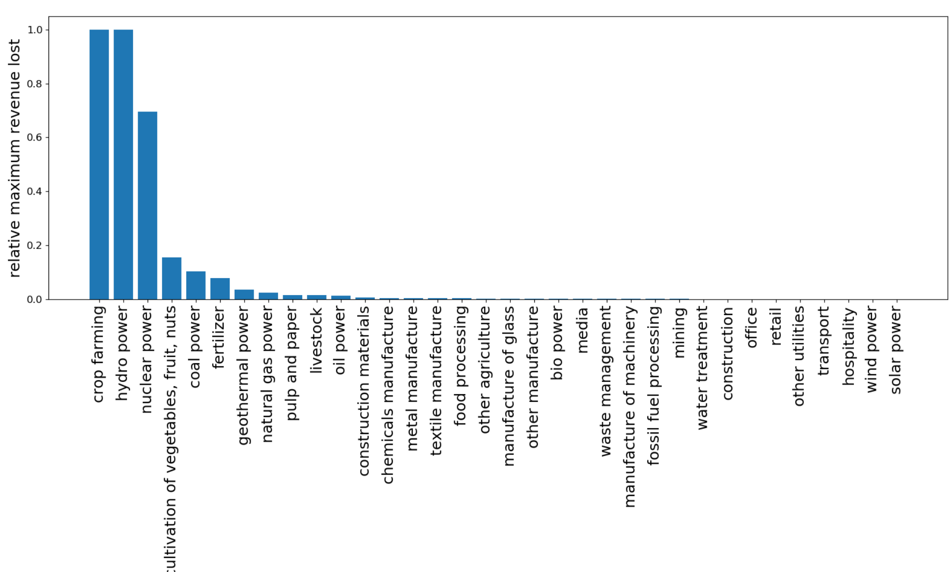
Sensitivity

The final step combines corporate data on water dependencies and water scarcity to a quantifiable measure. We create damage functions from the data presented in previous steps. There are studies on drought damages, but many of them focus on the agricultural sector or investigate only small regions (Aslam et al. 2017; Farhangfar et al. 2015; Li et al. 2018). Since our model aims to plot a global image of the economy and compare large corporations or sectors, a more general approach is needed. In this field, research comparing to multiple specific regional studies is scarce. Final damage values should approximate real damages, but do not claim to exactly represent real annual damages. Three main assumptions underlie the damage functions:

- Water intensities are a good proxy for estimating and comparing business sectors' dependency on water.
- The higher the water intensity, the more vulnerable a sector is in general.
- Costs increase with rising BWS values.

In order to reach this goal, damage functions were created in a two-step approach. First, we estimated a relative amount of revenue that is exposed to water scarcity. Following this assumption, we normalize all water intensities by the maximum water intensity, which is "crop farming." That results in a "relative maximum revenue" lost (Figure 2). Because hydropower is very dependent on water but shows a very low water intensity due to the Exiobase definition of water use, we calibrated it and also set it to a relative maximum revenue lost.

Figure 2: Relative Maximum Revenue Lost as Input for Damage Functions



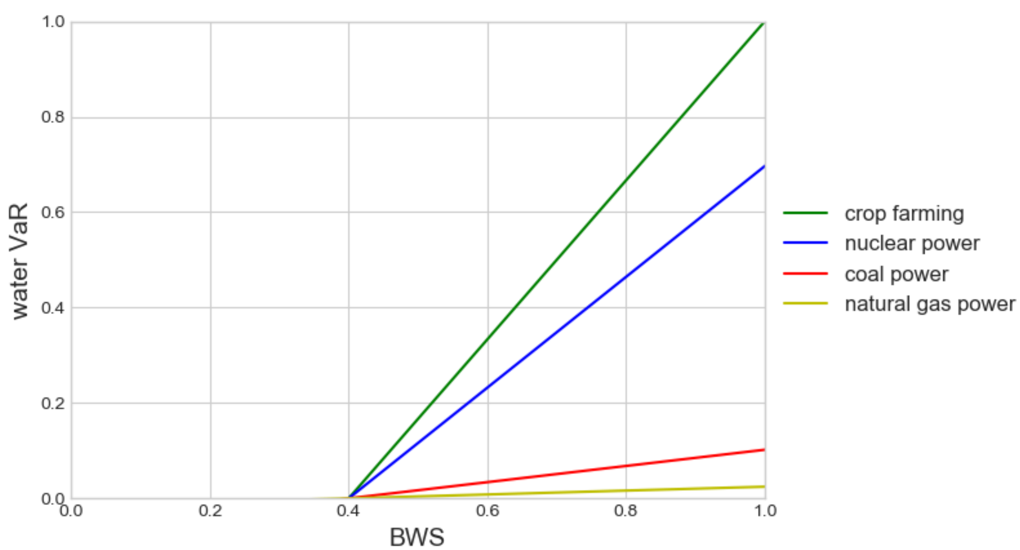
Source: *Author, 2019.*

In the second step, revenue dependencies need to be transformed into damage functions. In researching for a suitable shape and fitting for a damage function concerning water scarcity and/or drought, we found studies that promote linear damage functions in order to display economic costs of water scarcity under climate change conditions (K. Jenkins and Warren 2015; K. L. Jenkins 2012). This seems suitable as we also look at climate change effects - besides socioeconomic outcomes - and scenarios for water stress. Regardless, a linear function represents a simple positive relationship between stress values and computed damages. Since there is no data to fit to a type of function, we decided to stay with a simple relationship description. The positive linear relation represents the third main assumption that damages increase with growing BWS values.

According to this reasoning, we created the functions (Figure 3). Literature shows that from a threshold on average of 0.4 BWS, water stress causes effects on businesses (Alcamo et al. 2003; Reig, Shiao, and Gassert 2013). The maximum damage for every sector is the entire revenue share that we created in the earlier step when normalizing intensities. Returned values by the functions are named water Value at Risk (water VaR). We use this term when referring to other studies like Prettenthaler et al. (2016) that introduced the weather VaR. In contrast, we cannot apply any statistical risk to our data because we could not access hazard data that are resolved over time.

Figure 3: Selected Damage Functions for Four Different Sectors

The y-axis shows VaR as portion of revenue.



Source: *Author, 2019*.

Damage functions are applied to every single location of every company in the data set. At a location, the result of the sensitivity function (water VaR) is multiplied with the sector specific revenue that a company generates at this facility. Summing up these sectoral results allows showing how much revenue is at risk for every location and sector of a company.

$$VaR_{company} = \sum_{i=1}^{n} \sum_{j=1}^{k} R_j * f_i(BWS) \quad (6)$$

Where: i = number of locations, j = number of sectors, R = revenue, $f_i(BWS)$ *= VaR valu e at a specific location depending on BWS.*

In the end, water VaRs are divided by a company's revenue to show their relative risk level. For a use case, the model was applied to the iShares MSCI World ETF[1] as a rough representation of the world's economy.

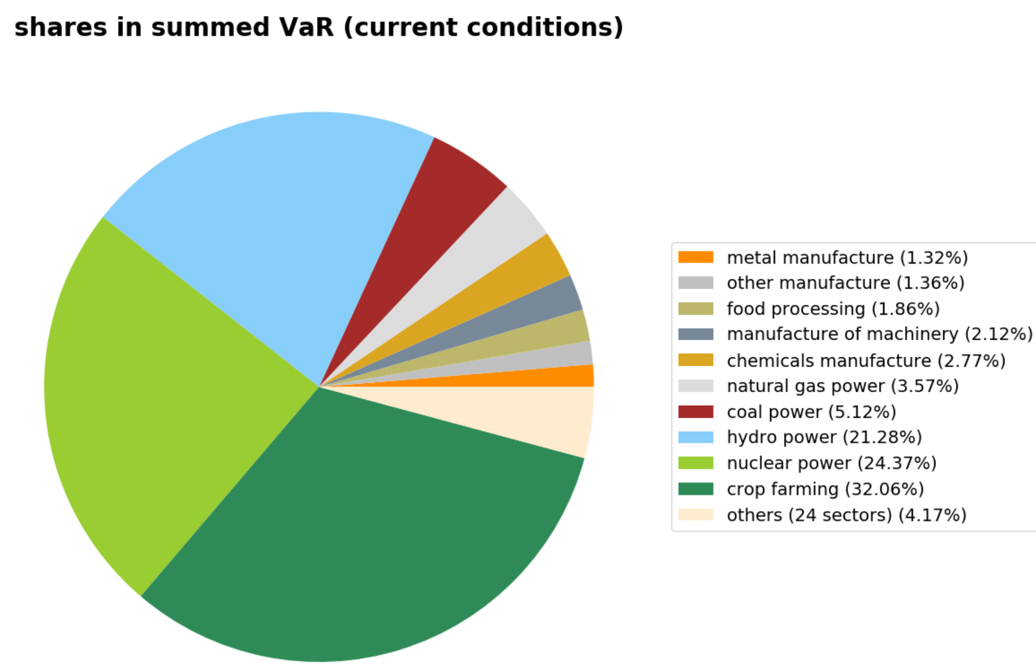
[1] Representation of ETFs through iShares by BlackRock. Included are the following ETFs: iShares MSCI World UCITS, Core S&P 500 UCITS, China Large Cap UCITS, EURO STOXX 50 UCITS, FTSE 100 UCITS, MSCI AC Far East ex-Japan UCITS, Core MSCI EM IMI UCITS, Core DAX® UCITS. CAC 40 is obtained through Euronext.

Results and Discussion

Our concept makes it possible to deliver several kinds of outcomes for decision makers on different levels. Of the sectoral shares of the overall VaR for the MSCI World, only three sectors (crop farming, nuclear power, and hydropower) are responsible for more than 75% of the total water VaR, while office activities (41%), manufacture of machinery (14%), and retail (8%) are the top three revenue generators in the index (Figure 4). The three most water-stressed sectors account for only 0.5% of the entire revenue created within the MSCI World.

This displays the concentration of water risk to only a small group of sectors. It is in line with the pattern seen in revenue vulnerabilities (Figure 2: As only a few sectors are assigned to very high intensities, the observed concentrations in VaRs result from our metric).

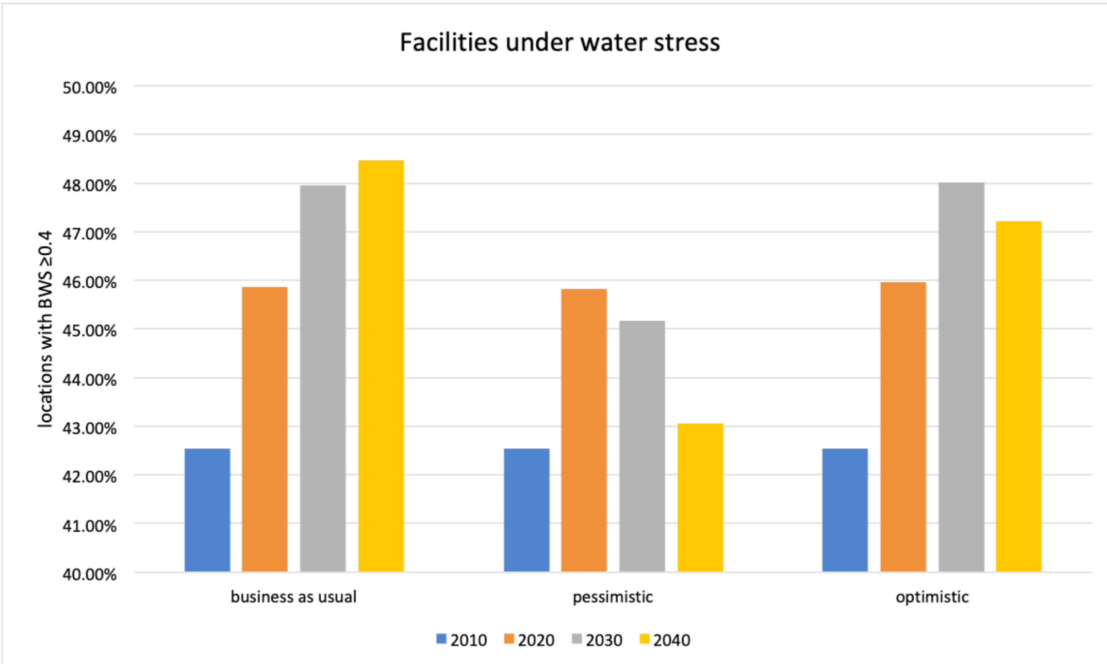
Figure 4: Sectoral Shares for the Overall VaR of the MSCI World
Percentages can be interpreted as parts of the total yearly VaR for the index.



Source: *Author, 2019.*

We examined three scenarios that show how risk locations of the MSCI World might develop over the next decades (Figure 5).

Figure 5: Share of Locations in Water-Stressed Catchments for the MSCI World Under the Three Scenario Ensembles Proposed by WRI



Source: *Author, 2019.*

Generally, all scenarios show a strong rise between the 2010 baseline year and 2020. This might be caused by a change in economic input data. While water use is primarily based on FAO data in the base year, it was estimated by regressions for all projections (Luck, Landis, and Gassert 2015).

Despite dealing with a climate that included high emissions and less favorable socioeconomic conditions in the pessimistic scenario, a decrease in the number of water-stressed facilities could be noticed. Regarding water, the business-as-usual scenario represents the worst case.

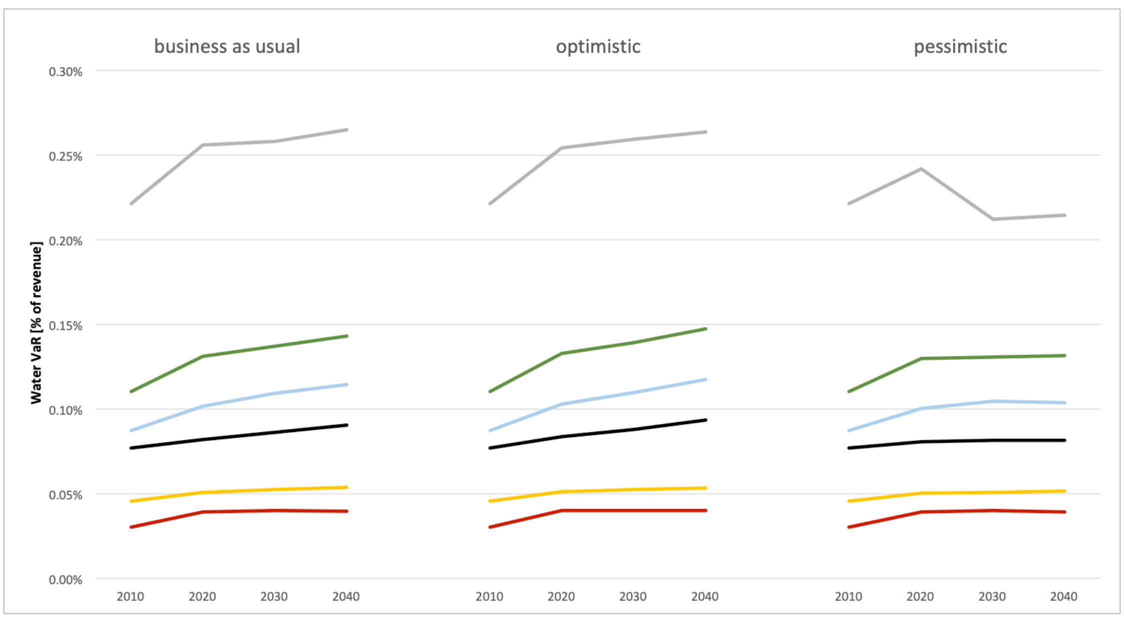
The pessimistic scenario is on average less hazardous than the business as usual. For most companies, the pessimistic pathways actually mean less risk. As the stress threshold of 0.4 is stable for all time steps, change in exposed locations is only driven by a shifting BWS. The WRI authors do not reveal the reason for it, but we assume that the proposed “slow” economic development of SSP3 leads to smaller consumption and accordingly to a lower stress level.

By contrast, we see a steady rise of stressed locations for the optimistic scenario until the number drops in 2030. We assume that economic activity causes a rise in water use and therefore pushes the BWS towards higher values. The drop at the last time step can only be explained by climate conditions, since the only difference between the business-as-usual and the optimistic scenarios is the RCP used for modeling. RCP4.5 leads to lower water stress in 2040 compared to RCP8.5 (ceteris paribus). So, for longer time scales, a decrease in greenhouse gas emissions causes lower annual water stress, at least for our sample.

Besides general views on indices, the model can be used to compare specific companies within a sector (Figure 6). As input data is partly confidential, names are not displayed. We observe that one company shows higher values by far than its competitors. Investors can use this information in order to build a "water-neutral" portfolio. At the same time, water VaRs are quite low compared to the total revenue of a company.

Figure 6: Example for a Competitor Comparison

Every color represents one major player in the chemicals sector and their development of VaRs under different scenarios. Companies are anonymous for privacy reasons.



Source: *Author, 2019.*

Because there is no data to fit against, absolute outcomes from the damage functions can pose only rough approximations to real values. Regardless, they might be more accurate when it comes to comparing sectors and companies. The strength of the presented methodology is that, by taking into account locations and revenue distribution for every single company, the model is able to provide comparisons for water risk exposure between sectors and individual companies.

The global approach inherits several uncertainties. First, damage functions probably differ in shape and steepness depending on region and sector. Water intensities forming the basis for vulnerabilities are also transformed to a global average and lack accuracy on a regional scale. The aggregation process from Exiobase to WRS contains limits in granularity of input data, and information is lost performing this step. Research shows that intensities also develop over time (Donnelly and Heather 2015), which has not been accounted for in the projections.

Sector mapping to revenue data poses a big uncertainty. In case of inaccuracies, revenues are assigned to wrong sectors and accordingly to wrong vulnerabilities. This probably represents the largest potential source of error since it affects the core of the data and had to be mapped manually.

For 17.8% of the MSCI locations, BWS is larger than 1. Here, our metric does not differentiate any more, although a BWS of 3 probably leads to a more intense regional water stress than a BWS of 1. The model does not enhance the VaR at these locations despite rising water-stress values. Further development of the metric can focus on how to deal with extreme water-stress values.

Also, on the hazard side, Aqueduct data delivers only annual values for water availability. Climate projections plot an increase of variability in precipitation on an intra-annual, monthly, and daily scale (Sun, Roderick, and Farquhar 2012). Besides, an increase in annual precipitation for many regions has been observed over past years (IPCC 2013). Therefore, for the future, an important impact might lay in variability.

Aqueduct does not account for water made available through desalination, leading to an underestimation of water availability in coastal regions. In later versions of the model, this issue needs to be resolved. As it is hard to globally estimate the contribution of desalination facilities, we did not perform this step for this first version of the model.

Outlook and Conclusion

Water risks are strongly concentrated in only a few business sectors, namely, agriculture, energy utilities, and some manufacturing industries. These sectors show the largest intensities and, accordingly, depend the most on water resources. For all sectors, this tool makes it possible to compare businesses' risk and relative exposure to water stress.

As risks are highly concentrated for sectors, errors in revenue allocation can lead to false risk attribution on a company level. For quality management, revenue distribution is therefore a crucial topic.

The model leaves room for follow-up research, especially regarding damage functions. Here, regional case studies can help to further quantify water-related damages, fitting regional damage curves and allowing a global image for how water influences businesses.

For a more granular hazard assessment, temporally resolved data is needed in order to define events. Moreover, an event-based approach would need several sources of water availability, such as stream-flow or precipitation, to tailor water risks to specific sectors.

Finally, the current version of the model is ready to be used for ESG purposes. Only minor changes could add a scaling for water stress on a portfolio and on a company level.

A fitting of damage functions, including reported damages, would make the model available to estimating and predicting real damages. For now, the presented approach provides insight on what is currently possible with available data and builds a methodological framework for follow-up research.

Acknowledgements

I would like to thank the entire team of Carbon Delta AG for providing crucial data as well as important feedback. As this paper is the published form of my master's thesis, I would like to give a big thanks to my family who supported me not only during the conception and writing of the thesis, but throughout my studies. Without you, I could not have gone this way.

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Biography

As a data scientist, **David Bokern** works on model development and natural hazards at Carbon Delta AG, a research company assessing climate change effects on publicly traded companies. After earning a BSc in Environmental Sciences at Leuphana University Lüneburg, he developed skills in environmental modeling in the field of physical geography. Upon completing his coursework studies for the Master of Science in Environmental Systems at Ludwig-Maximilians-University in Munich, David Bokern wrote his thesis, with the cooperation of Carbon Delta AG, about global water stress on financial markets.

A Comment on "Water Stress: A Global Risk Analysis for Financial Markets"

Angelo Calvello, PhD
Publisher of the *Journal of Environmental Investing*

Mr. Bokern's original essay provides investors with what I believe to be the first robust and practical framework for the analysis of water risk. Many investor-friendly "tools" tend to be purely descriptive (e.g., Ceres Water Risk Toolkit) and offer no holistic model for estimating and predicting an investment's or portfolio's true exposures to water risk. (In fact, such tools seem to expose investors, especially pension funds, to fiduciary risk because they identify a material risk but fail to offer a means of properly measuring the risk. This is like a fiduciary knowing that it has exposure to U.S. interest rates but no understanding of convexity or duration.)

Importantly, Bokern's research moves beyond these pedestrian approaches and even the current scientific method of using drought indices to estimate water risk and offers a methodology for determining hazard, exposure, and sensitivity for publicly traded companies on a global scale. While Bokern's methodology must be identified as a work-in-progress, because of the exigency of water risk, it is of immediate value to investors since "by taking into account locations and revenue distribution for every single company, the model is able to provide comparisons for water risk exposure between sectors and individual companies."

Riding the Waves of the Blue Economy: Implications for Impact Investors

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Ocean ecosystems around the world are increasingly impacted by coral bleaching, pollution, and declining fish stocks (Allison and Bassett 2015; Hughes et al. 2017). Simultaneously, oceans are seen as development frontiers, offering opportunities for growth and attracting the attention of businesses and governments alike (The World Bank and United Nations Department of Economic and Social Affairs 2017). For some, the Blue Economy articulates this potential by proposing to save oceans while harnessing their economic potential (Winder and Le Heron 2017). Others fear that the growth of a Blue Economy that is not explicitly pursued as sustainable may lead to "irreversible damage" (GEF 2018). Although it is not always clear what the Blue Economy means, definitions generally include social, economic, and environmental improvements. A successful Blue Economy should be capable of balancing social, economic, and environmental benefits, resulting in sustainably managed oceans.

But finding a way to sustainably finance and manage our oceans is a task that is as important as it can be difficult. In this commentary piece, we aim to contribute to the ongoing discussion on how to best finance sustainable and socially inclusive marine investments. We do so by elaborating specifically on risks and social inclusion for investments in the Blue Economy, two issues that are critical and currently challenging to grasp (Accenture, 2017). We first describe how the concept of the Blue Economy is currently applied and comment on the risks associated with using this often-ambiguous concept. Second, we expand on the notion of social inclusion in the Blue Economy. Drawing on fishery research, we argue that an expanded notion of social inclusion could not only improve fleet resiliency, but also decrease investor risks. We finish by posing some questions for investors who are interested in pursuing a Blue Economy that is balanced across its varied interests and stakeholders.

Conceptualizing Blue Investments

While the concept of the Blue Economy has thus far attracted mass attention from a wide spectrum of stakeholders, including investors, what the Blue Economy and its investments should look like is not always clear, and at times claims about the Blue Economy contradict one another. For example, some claim that the Blue Economy is about maintaining natural capital at an environmentally sustainable level, while others claim the Blue Economy is compatible with oil exploration and deep-sea mining (Silver et al. 2015; Voyer et al. 2018). Furthermore, despite the frequent reference to society within the Blue Economy discourse, a report by Accenture (2017) concluded that few definitions of the Blue Economy promoted social inclusion. Despite these findings, the promise of a Blue Economy that can simultaneously pursue growth, social inclusion, and sustainability (World Bank and United Nations Department of Economic and Social Affairs 2017; WWF et al. 2018) has most likely been critical to making marine investments compatible with impact investment.

As a concept, the Blue Economy is ambitious, promising, and difficult to disagree with: The promise of win-win-win situations means that many stakeholders can rally behind it because something resonates with them (Winder and Le Heron 2017). Thus, the Blue Economy can be seen as a boundary object—an idea flexible enough for divergent stakeholders to subscribe to, but one that can also take on a structured state when applied in a specific situation (Star 1989). Boundary objects are useful because they allow a large variety of stakeholders to find common ground and open up conversations about multifaceted issues. The Blue Economy is a good example of a boundary object because, in its very definition, it includes social, environmental, and economic interests. However, a risk that has been identified with boundary objects in general, and the Blue Economy in particular, is that they can come to mean anything, and that seemingly incompatible uses of the ocean (for example the simultaneous concern for sea-level rise combined with the effects of extractive industries such as oil and gas exploration) are not recognized, discussed, or addressed. The lack of consensus about what the Blue Economy is, or should be, and the lack of recognition of these differences (Silver et al. 2015; Voyer et al. 2018), exacerbates this issue.

For investors confronted with this abundance of meaning, the Blue Economy represents both an opportunity and a risk (Voyer and van Leeuwen 2019, 111–112). On the one hand, ambitious impact investors can use their investments to show that environmental sustainability and social inclusion are necessary conditions for any investments in the Blue Economy. In other words, investors can set high standards and be able to push blue investments in a sustainable and socially inclusive direction. *The Sustainable Blue Economy Finance Principles* by WWF et al. (n.d.) can be seen as a decisive move in this direction. However, the ambiguity of the Blue Economy concept also presents a communicative challenge for investors, since many people on the ground may not see the Blue Economy as representing social inclusion and environmental sustainability (Schutter and Hicks, in press), regardless of what the intentions of blue investments might be. Insofar as other investors (as well as policymakers) are unable or unwilling to make or enable investments that will have an impact, investments that claim to be part of the Blue

Economy may not be seen as legitimate. Earlier discussions by those in the green economy have shown that a critique of greenwashing can quickly emerge, even if such a thing is in fact not widely spread (Pope and Wæraas 2016). As long as Blue Economy investments are not explicit about the "blueness" of their investments, similar critiques might emerge over what products or investments are truly blue.

Social Inclusion in Maritime Investments

In this section, we want to focus on social inclusion within the Blue Economy and how inclusion can go beyond increasing income for fishers. As organizations such as the Environmental Defense Fund and Nicholas Institute for Environmental Policy Solutions at Duke University (2018, 10) recognize, economically compensating fishers and other stakeholders that may be negatively affected by altered fisheries governance is a central challenge if fishery reforms are to become feasible. While we do not want to underestimate the importance of economic compensation for fishers, we argue that social aspects of the Blue Economy go beyond improving livelihoods by increasing people's incomes. Social inclusion also involves political and cultural issues such as consultation and appreciation of cultural and other nonuse values of the environment, rather than purely economic concerns. Environmental values are defined here as the societal importance that is ascribed to nature (Kenter 2018), and the extent to which these are addressed and engaged with can affect whether investments can gather stakeholder support.

First, if fishers do not feel that they have been taken into account during the decision-making process, they may very well perceive the outcome as unfair. Even if a given investment does not leave them economically worse off than before, perceived unfairness can still negatively affect collaboration in the future. Instead of focusing on the outcomes for stakeholders, further attention could be paid to procedures that allow local stakeholders' values and active participation to be recognized in the planning process (Bennett, 2018, 140; 2019, 76). Including local fishers in decision making is not just about securing their fishing rights; securing an inclusive decision-making process can also be seen as a way of integrating social sustainability as part of the decision process. Thus, including stakeholders would ideally go beyond just having stakeholder consultations, which are considered ad hoc, to ensuring that power and responsibility are shared between local stakeholders and governments (Berkes 2009). While free, prior, and informed consent (FPIC) is of course a widely acknowledged principle for impact investors, further inclusion of coastal communities in decision making would move beyond FPIC; it would let coastal communities be involved in defining what the Blue Economy should look like. For ambitious investors, this could even be a way to mitigate risks since it could lead to a local feeling of ownership over the project. If people find a mechanism or agreement legitimate, they will also be more likely to comply with its terms. Including people at an early stage can therefore easily lead to mutual benefits.

Despite numerous studies showing that people in coastal communities and elsewhere value (ascribe importance to) marine ecosystems beyond direct use values (e.g. Brander, Van Beukering, and Cesar 2007), these nonuse values are still often measured through methods that translate them into monetary values (Gómez-Baggethun et al. 2010). More recent research in ecosystem services has advanced the argument that by measuring these values in monetary terms, we lose out on nuance and understandings about the importance of ecosystems for human well-being (Chan et al. 2012). The research also indicates that different types of values can be incommensurable and therefore cannot be measured along a single scale (O'Neill 2002). Coastal communities and fishers value marine resources and their interactions with the ocean for a variety of reasons that are both monetary and nonmonetary (e.g. identity, aesthetics, natural history, arts, and culture). For example, as we have experienced during previous research and as others have demonstrated as well, fishers often see fishing as an occupation that entails a lot of freedom and the possibility of being one's own boss, thereby contributing to important values connected to culture and identity (Cohen et al. 2019; Høst and Christiansen 2018; Weearatunge 2014). This view indicates that fishing is more than a way of sustaining an income. Therefore, while translating environmental and social concerns into economically comparable prices might aid inclusion in the policy process in the short run, the long-term consequence could be a prolonged imbalance in the triple bottom line of the Blue Economy, precisely because people benefit from and value oceans in a variety of ways.

Thus, it is important to acknowledge that although ecosystem services expressed in monetary values can sometimes illustrate opportunities for investors or planners, they can also obscure qualitative differences in values. If people on the ground ascribe importance to ecosystems and the services they provide because they contribute to their identity, culture, and political relationships, their appreciation of these benefits will not likely be expressed in money. When assessments only allow for monetary valuation, they can lead to decisions that risk a lack of stakeholder support as well as a lack of recognition and effectiveness in terms of covering the benefits from ecosystems. Therefore, it is paramount that the complexity of the social pillar and the plurality of values be maintained when making decisions about impact investments. While a focus on economic valuations and benefits provides a concept of social inclusion that is easy to implement, more geographically specific assessments, which are not easily reduced to monetary values, need to be included as well.

Furthermore, on a community level, informal ways of governing ocean resources, such as rules for access, sharing, and pricing, can play an important role for food security and social cohesion (Menon et al. 2018). Such local rules for governing, say, of fishing, need to be considered in order to reduce the risk that socially inclusive and environmentally sustainable local practices become disrupted. Even if local ways of governing fisheries are unsustainable, it is equally important to acknowledge that rather than being purely motivated by economic interests, informal ways of governing fisheries may be linked to existing social status and food security issues or local notions of health. For example, if a coastal community has a long history of fishing, transitioning to other forms of employment may not be seen as desirable even if it secures incomes. Moreover, jobs resulting from alternative livelihood projects may not even be feasible or accessible for some stakeholders that are affected. Benefits from alternative livelihoods can be unevenly distributed, thereby failing to reach those who need them (Bennett and Dearden 2014). It is therefore critical to continually consider how the social impact of investments is distributed, ensuring that social benefits outweigh potential social costs. In short, in addition to understanding local modes of governing—whether sustainable or not—it is important to understand who is fishing, how they are fishing, and why they are doing so. These considerations should be part of due diligence and stakeholder consultation and be recognized prior to an investment or a potential change of governance exactly because existing social practices can serve either as a barrier or as part of the solution to achieving sustainability and social inclusion.

Once an investment has been made, investors will need to develop and apply key performance indicators (KPIs) that can facilitate the investors' social, economic, and environmental targets. The complexity of marine ecosystems and that of the societies and industries that derive services from them of course calls for too great a variety of related KPIs for us to review them all. One of the central marine investment KPIs for fisheries in general is catch per unit effort (CPUE), which is often used as an index for abundance of a targeted species. For commercial purposes, other KPIs, such as profit per unit effort (PPUE), are sometimes used to further account for incomes and expenses. While a KPI like PPUE is relevant for understanding business operations, it may need to be supplemented by other metrics. This is because a sole focus on profitability can be an incentive to fish for species with the highest sales market price. Furthermore, a focus on PPUE can lead to a restructuring of the fishing capacity. During periods of environmental uncertainty, however, fishers' resilience can increase by fishing for a variety of species. Maintaining the capacity to fish for diverse species can thereby enable long-term economic and social resilience. Gear and boat types can influence flexibility when fish stocks are changing in size or composition (Cinner et al. 2015; Musinguzi et al. 2016). For example, local circumstances and practices can prove decisive in the outcomes of events such as coral bleaching. Indeed, in Seychelles, the variability of fish catches increased and their composition changed after coral-dominated reefs became algae-dominated as a result of habitat collapse from coral-bleaching events (Robinson et al. 2019). More variability in catches and changing species compositions are but one example of changing local conditions that generalized KPIs do not account for.

Moreover, if the Blue Economy is about balancing the triple bottom line, investments should also engage with priorities across the pillars and within them. We addressed the extent to which the power balance is slanted toward the economic pillar by addressing the Blue Economy from an investment perspective. However, imbalances can also be found within pillars as well. While stakeholder consultations can give a voice to local communities, they can also overlook those actors that are unable to make their claims heard because of how planning is designed (Fairbanks et al. 2018). Those stakeholders that have power might be better able to navigate processes like Marine Spatial Planning and ensure that their voices are being heard. *Their* social pillar is less likely to be compromised through a lesser ability to participate in decision making than the social pillar of less powerful stakeholders. This way, the Blue Economy can contribute to increasing and entrenching power imbalances. Navigating these aspects can be as difficult as they are important to keep track of.

More transparency on the actual trade-offs involved in Blue Economy investments could contribute to a clearer image of who the winners and losers are, and through which values they are affected.

Conclusion

The three pillars of the Blue Economy are sometimes aligned; at other times, they are at risk of conflicting with each other. A balance between the three therefore must be sought continuously. The economic and environmental pillars are often seen as mutually necessary, but the social pillar often finds its way into the equation only when it is translated into economic terms. However, environmental and social concerns are more than just economic indicators. Environmental concerns can find their way into economics-based decision making through the concept of ecosystem services (and only when these services are translated into monetary terms, leading to underrepresentation of cultural and relational values).

In summary, the different ways in which people express the importance of nature as exchange values can lead to a loss of information, potentially resulting in certain values being underestimated or underrepresented. As a result, we suggest that investments could pay more attention to local conditions when assessing social impact and inclusion. We encourage investors to ask questions about what is hiding between aggregate improvements, notably on the distribution of benefits between and within pillars, and especially regarding the social pillar. Important questions also involve the extent to which these ideals are, and can be, turned into concrete projects and reforms. By considering alternative goals for social impact and inclusion (for example, through participation in decision making or by maintaining local cultural practices), investors are able to steer clear of the oftentimes-blurred line that arises from making social inclusion synonymous with increasing incomes. To accomplish these goals, a central concern will be how to include the currently excluded KPIs as a way to further balance different interests in the Blue Economy. The advantages of such robust processes will naturally have to be considered alongside the organizational burden that comes with monitoring them. We hope, however, that the merits of the former outweigh the demerits of the latter.

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Biographies

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Marleen Schutter is a PhD student at Lancaster University, where she researches processes of value articulation for ecosystem services and the Blue Economy as forms of environmental governance. Her research interests range from interdisciplinarity in ecosystem services to perspectives on the Blue Economy in different international and national domains, including in Seychelles national policy making. A key question in her research is to ascertain to what extent these different domains interact with values and perceptions of resource users. Originally from the Netherlands, she completed a Bsc in Economics at Radboud University and an Msc in Environment and Resource Management at VU University.

A Comment on "Riding the Waves of the Blue Economy: Implications for Impact Investors"

John Hoeppner, Head of U.S. Stewardship and Sustainable Investments
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The authors make a compelling case to carefully consider the social context before jumping into the deep end of ocean investing.

While there are mature timber, farmland, and real estate funds and strategies, the ocean economy is a nascent area for investing. The authors thoughtfully point out that as this field of investing emerges (Blue Economy matures), it is paramount that investors and other market participants balance economic interests with complex societal issues. As frameworks are established, it is uniquely necessary that local people be brought in to participate in the creation of goals and measurement approaches. The mainstream institutional investment community largely lacks these skills in-house, so governments, development banks, NGOs, and others will likely need to lay the groundwork.

In future pieces, it would be great to further explore the social benefits, expand on the social key performance indicators (KPIs), and highlight the financial prospects and characteristics of a thriving ocean economy.

Responsible Investment in Blue Carbon Resources: "Constraints and Potential Motivations for Attracting Private Capital Investment in Blue Carbon Resources"

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Abstract

Blue carbon ecosystems such as mangroves, tidal marshes, and seagrasses are increasingly recognized for their carbon sequestration capacity. While blue carbon science and policy research is advancing, private investment perspectives in relation to blue carbon are limited. Within this context, there are emerging shifts in global private capital markets aimed at more measured capital deployment and responsible investment. Such shifts often align with the United Nations Sustainable Development Goals (SDGs) and are guided by initiatives such as the United Nations Principles for Responsible Investment (PRI). This study uses an anonymous online survey and quantitative exploratory analysis of the perspectives of 44 large-scale private investment respondents, primarily from Australia. Respondents were segmented into actors with for-profit and not-for-profit motives. Key research findings were the comparatively low levels of respondent familiarity with the term *blue carbon* compared to similarly themed terms. This finding was supported by respondents indicating a low level of knowledge relating to carbon market investments. Respondents remained focused predominantly on return on investment (ROI), but many viewed associated co-benefits as an important factor when considering large-scale investment. This research expands on existing knowledge of investment in blue carbon with a more targeted focus on private large-scale investment motivations and constraints. Drawing on research findings, a conceptual model of blue carbon market constraints and motivations was developed.

Keywords: blue carbon, responsible investment, private investment, ESG, conservation finance

Acronyms and Abbreviations

AGEDI	Abu Dhabi Global Environmental Data Initiative
BC	blue carbon
ESG	environmental, social, governance
GEF	Global Environment Facility
IPBC	International Partnership for Blue Carbon
IUCN	International Union for Conservation of Nature
NGO	non-governmental organization
PRI	Principles for Responsible Investment
RI	Responsible investment
ROI	return on investment
SDGs	Sustainable Development Goals
TCFD	Task force on Climate-related Financial Disclosures
UNEP FI	United Nations Environmental Program, Finance Initiative

Responsible Investment in Blue Carbon Resources

Blue carbon is a term used to define the capacity of coastal ecosystems (including mangroves, salt marshes, and seagrass) to sequester and store carbon (McLeod et al. 2011). Despite occupying 0.2% of the ocean surface, blue carbon (BC) resources contribute up to 50% of carbon burial in marine sediments (Duarte et al. 2013). BC ecosystems are powerhouses of carbon sequestration and storage with a carbon yield per unit area far greater than terrestrial ecosystems (McLeod et al. 2011). While BC science and policy dialogue advances, there is a notable absence of BC literature (academic and gray) focused on private sector perspectives, in particular relating to investment priorities and financial mechanisms (Thomas 2014).

For the most part, existing investment in BC comprises government and non-governmental organizations (NGOs), sometimes working in partnership Bayraktarov et al. 2016). Large-scale BC initiatives such as Global Environment Facility (GEF) Blue Forests; Abu Dhabi Global Environmental Data Initiative (AGEDI) Blue Carbon Demonstration Project; and the Yokohama Blue Carbon Project constitute multiple stakeholder programs that receive support underwritten by government agencies.

However, BC ecosystems are increasingly threatened. Global estimates of decline in BC ecosystems range from 340,000 hectares to 980,000 hectares destroyed annually in the past 50 to 100 years (Murray et al. 2011). Aside from carbon sequestration and storage, BC ecosystems provide a wide range of co-benefits for stakeholders, including coastal protection, improved fisheries health, sediment retention, and watershed protection and purification (Yee 2010).

A diversity of co-benefit income streams associated with BC investment benefits both investors (by reducing risk and potentially increasing returns) and local community stakeholders. For example, the Mikoko Pamoja BC project in Kenya has benefitted from "diversifying sources of mangrove-related income, such as beekeeping and ecotourism" (Wylie, Sutton-Grier, and Moore 2016). Therefore both income streams and co-benefits are important for positive private investment outcomes.

Responsible Investment

Responsible investment (RI) can be defined as "a process that takes into account environmental, social, governance (ESG) and ethical issues into the investment process of research, analysis, selection and monitoring of investments" (RIAA 2018). Globally, US$89.6 trillion is managed by stakeholders who are signatories to the United Nations Principles for Responsible Investment (PRI 2018).

The RI market is analogous to what some actors may classify as environmental, green, and sustainable investment with methodologies often intersecting. Broadly, these investment markets can be categorized into five groups: carbon; financing solutions for land use, land-use change, and forestry; clean technology; sustainable property; and water (Calvello 2010).

Sustainable Development Goals

With the advent of the United Nations Sustainable Development Goals (SDGs) in 2015, clearer investment pathways have emerged. What also became clear is that governments and intergovernmental agencies do not have the financial resources to meet the ambitious goals alone, so private investment mobilization is required (OECD 2016). Within this RI context, SDGs numbers 14 (“life below water”) and 13 (“climate action”) are most directly linked to BC. More broadly, the International Union for Conservation of Nature (IUCN) suggests 10 SDG targets can be achieved by protecting and restoring mangroves (Blum and Herr 2017).

Private Investment Opportunities

The United Nations PRI was established in 2005 and aims to provide guidance for private investment actors. The analysis of investments guided by the PRI estimates close to US$60 trillion in assets under management (Friede, Busch, and Bassen 2015). Projecting forward, it is estimated that up to US$7 trillion in new investment is required per year to 2030 in order to remain below the 2°C guardrail for climate change (OECD 2017).

For the purposes of this research, large-scale private investors are defined as entities with significant financial resources, expertise, and knowledge in investment. This includes pension funds, institutional investors, philanthropy, and retail investors (Huwyler et al. 2014). This study aims to understand the existing constraints and potential motivations for large-scale private investment in BC.

As a result of the systematic literature review process, we defined our fundamental research questions. First, is a dearth of blue carbon literature relating to finance and private sector perspectives constraining large-scale private investment? Second, with substantial private capital required to achieve the SDGs and significantly decarbonize, what can motivate targeted large-scale private BC investment?

We conducted an exploratory quantitative analysis of the current RI landscape with a focus on private investor perspectives. Prior to screening, 55 completed responses were received with a response rate of 40%.

Survey Methodology

The aim of this study was to analyze potential constraints and motivations to attracting large-scale private capital investment in BC resources. Exploratory data analysis was applied, defined as "an attitude, a flexibility, and a reliance on display, not a bundle of techniques" (Tukey 1980).

Survey Design

The survey design was intentionally brief, given that the respondent sample primarily comprised busy professionals based in Australia. Survey questioning was designed with adequate breadth and depth to provide rigorous exploratory data. This combination of brevity and selective depth is advocated to improve response rates among busy clinicians (Sahlqvist et al. 2011).

Respondents were required to answer 18 thematically clustered questions. The survey was anonymized from the point of distribution to increase the likelihood of statistically meaningful response rates. Rationalization for this approach was primarily the sensitive, proprietary nature of investment fundamentals among respondents and their organizations. Language was tailored to favor investment nomenclature to avoid marginalizing respondents.

The private investment sector includes a wide spectrum of actors, which can increase variability in survey responses. We chose to merge respondent entity categories to private for-profit and private not-for-profit. Respondents matching the aforementioned criteria who provide third-party investment advisory services to investors were also included in the survey.

Demand bias was identified as a possible impediment to data integrity. Disclosing BC as the topic of research could inflate BC-associated value among respondents as "asking the respondents about preferences for a public good could signal that the good is important and has significant value" (Carlsson, Kataria, and Lampi 2018). To reduce demand bias we did not disclose the topic of the research, rather the survey was described as focusing on responsibly themed investment.

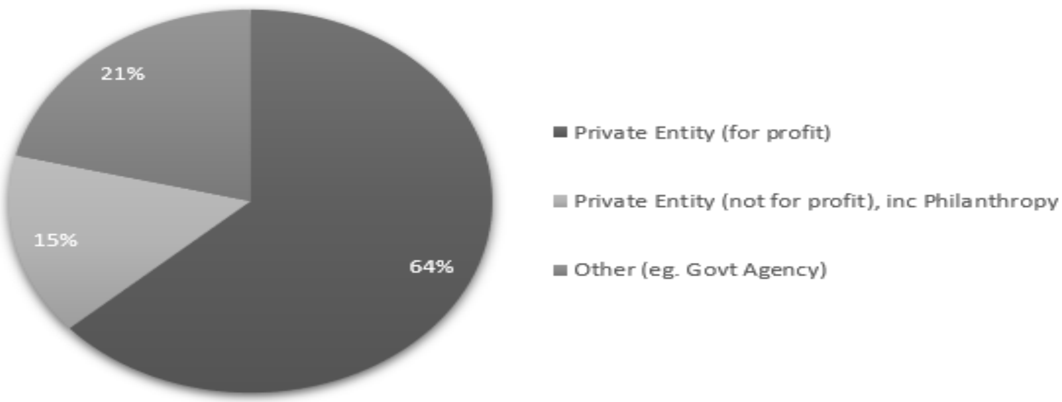
Results and Discussion

This section covers details of the survey screening and discussions of the respondents' familiarity with BC and their opinions regarding constraints to investments in the carbon market.

Survey Screening

Excluding 11 non-private entity respondents (a result of initial respondents sharing the survey), an aggregation of the 44 private-entity survey responses was completed. Private for-profit entities represented 64% of all respondents, while private not-for-profit entities (including philanthropy) represented 15% of responses. Overall, a private respondent representation of 79% was deemed a sufficient sample (Figure 1).

Figure 1. Respondent Representation (n=55)



Source: *Author, 2019.*

Secondary screening was conducted to focus on RI practitioners. Ethical investment criticality in the investment decision-making process provided a snapshot of investor preferences and alignment with RI methodologies. The importance of ethical investing was scored from 0 to 5, with scores of 0 to 2 indicating low priority, scores of 3 and 4 indicating medium priority, and a score of 5 indicating high priority. Overall, 71% of respondents rated ethical investment as a high priority (i.e., a score of 5). This majority of respondents viewed ethical decision making as essential, providing further validation that the target respondents fulfilled the research criteria.

Respondent Familiarity with Blue Carbon

A baseline was assessed to ascertain current knowledge levels among respondents. Responses were elicited with the ranked categories “very familiar,” “slightly familiar,” and “not familiar at all.” Cross-tabulation analysis of respondents was completed with question three of the survey: “Has your entity (or an entity you advise) previously invested financially in a predominantly environmentally themed project or initiative?” The inferred relationship being that respondents who had previously invested in an environmental initiative were more likely to be familiar with BC. Overall, 41 of the 44 (93%) private investment respondents identified as having previously invested in a predominantly environmentally themed project or initiative.

Despite this, BC rated equal to the lowest in familiarity among respondents, with 18 “very familiar” responses (Table 1). Respondent familiarity with more anthropocentrically focused terms such as carbon farming, green bonds, and green infrastructure provides a clear contrast, with the lowest-ranking anthropocentric term (“conscious capitalism”) obtaining 24 “very familiar” responses (Table 1). Further uncertainty regarding the phrase “slightly familiar” could imply that 59% of all private respondents had very little to no knowledge of BC.

Table 1. Respondent Familiarity with Environmental Terms, Measured as the Number of “Very Familiar” Survey Responses

	How familiar are you with these terms?								
	Carbon sequestration	**PES[1]**	**Conscious capitalism**	**Green infrastructure**	**Blue carbon**	**Natural capital**	**Carbon farming**	**Green bonds**	**Impact investing**
Private for-profit	25	12	21	27	13	19	21	23	26
Private not-for-profit	9	6	3	8	5	8	9	9	9

[1] PES: Payments for ecosystem services

Source: *Author, 2019.*

A measure of respondent familiarity with more developed investments initiatives (such as the SDGs) was also undertaken. Familiarity with the more institutionalized International Partnership for Blue Carbon was significantly lower than with the term BC itself (Table 2). Acknowledging the global scale and predominantly financial focus of comparable institutional organizations (particularly the United Nations initiatives), the familiarity deficit presented in Table 2 is no less marked.

Table 2. Respondent Familiarity with Responsible Investment Initiatives

	Rate your familiarity with the following organisations and principles? (very familiar responses #)				
	UN SDGs	TCFD	UN PRI	IPBC	UNEP FI
Private for-profit	20	12	11	5	6
Private not-for-profit	5	4	5	2	3

[2]

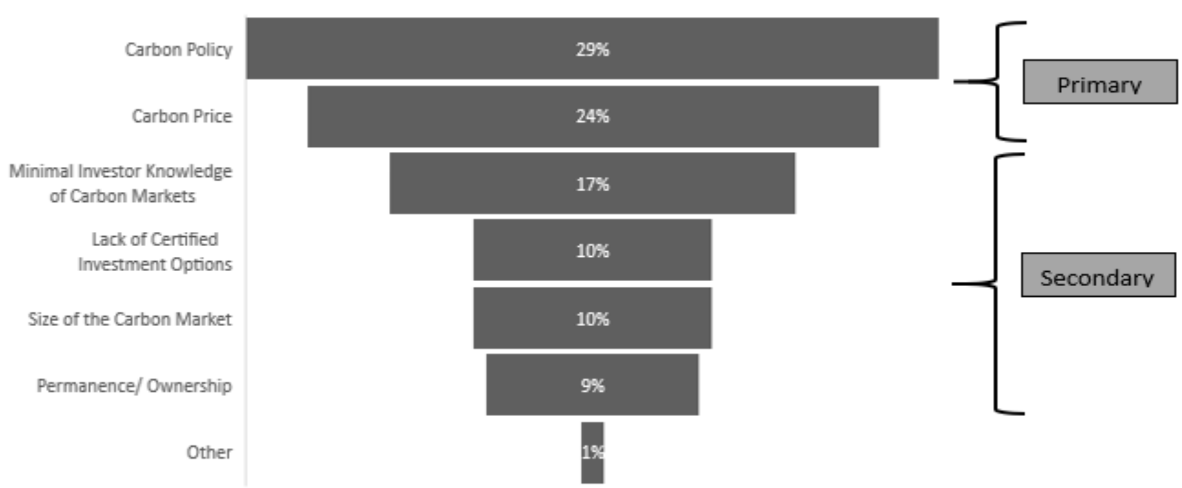
[2] SDGs – Sustainable Development Goals; TCFD – Task force on Climate-related Financial Disclosures; PRI – Principles for Responsible Investment; IPBC – International Partnership for Blue Carbon; UNEP FI – United Nations Environmental Program, Finance Initiative

Source: *Author, 2019.*

Carbon Market Constraints

Respondents were asked to identify the three most significant constraints to large-scale investment in the broader carbon market. An improved understanding of constraints provides a foundation for removing obstacles and potentially increasing private BC investment. Primary constraints on carbon market investment identified by respondents focused upon carbon policy and carbon price (Figure 2). Policy and price uncertainty correlates with investment uncertainty and risk.

Figure 2. Carbon Market Constraints Respondents (n=44)



Source: *Author, 2019.*

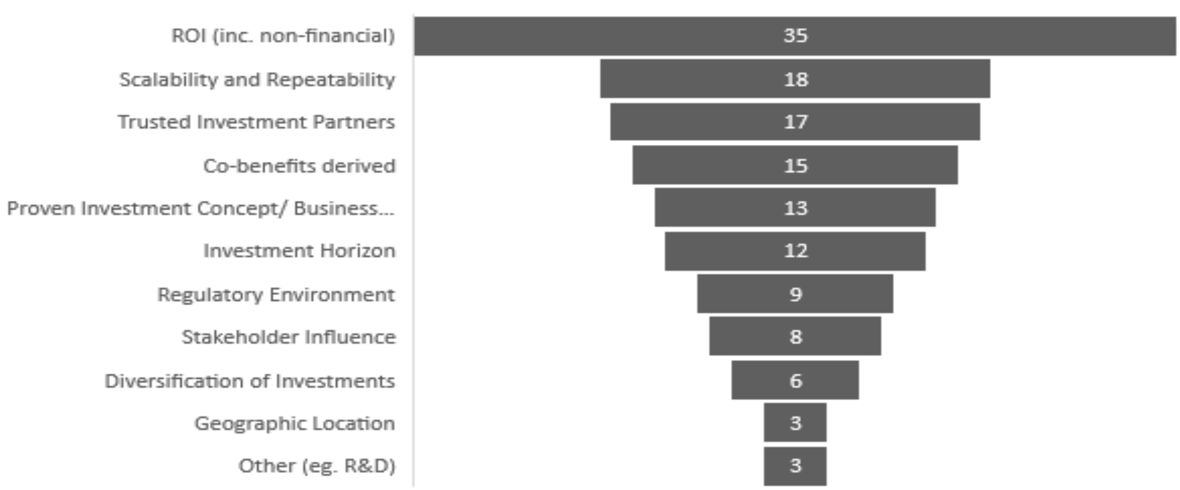
With 17% of respondents acknowledging they have minimal knowledge of carbon markets, a concern for BC stakeholders is that this is an investment "dead zone." The more unknown an investment, the more likely that investment will be sidelined. Permanence and ownership constraints (9% of responses) require appropriate legal structures for rightful claims to carbon offsets generated by a BC initiative.

While such constraints could be viewed as detrimental to large-scale private investment, BC stakeholders should view this reality constructively. Such fundamental risks with carbon market investments are not confined to BC but impact all carbon-offset initiatives. Although these issues may be more nuanced for BC, they may be addressed with similar approaches to terrestrial carbon-offset projects.

Motivations for Investment

To better understand motivations for investment, respondents were asked to identify the top three factors for considering large-scale investment (Figure 3). What is clear from respondent results is the importance of return on investment in decision making (25% of all responses). This result complements published literature suggesting that large-scale institutional investors are primarily motivated by financial rather than ethical reasons (Amir and George 2018). Scalability and repeatability are also fundamental in private investor decision making, particularly for large-scale investment. Scalability describes an investment's ability to grow profitably (Nielsen and Lund 2018). An investment with the capability to scale is more likely to deliver improved returns, ostensibly a more attractive investment proposition.

Figure 3. Important Factors for Large-Scale Investment, Number of Responses (n=44)



Source: *Author, 2019.*

When addressing the return on investment and scalability requirements of private investors, sequestered carbon yield should be a focal point for BC stakeholders. BC ecosystems are up to 10 times more effective at carbon sequestration (McLeod et al. 2011) and twice as effective at carbon storage (Murray et al. 2011) than terrestrial ecosystems. This point of difference speaks directly to the return and scalability parameters private investors seek.

"Co-benefits derived" ranked highly, comprising 11% of responses. Effective financial translation of purported theoretical co-benefit values with BC investment is key (Lau 2013). The proximity of BC ecosystems to existing investments could facilitate effective financial translation of co-benefits for private investors (for example, existing aquaculture investments). By relating quantifiable effects to existing assets or income streams, investors can more accurately account for associated BC co-benefits. Accepted notions of opportunity cost and cost-benefit analysis can be used for investment decision making in these instances. Broadening the total financial and economic value of an investment could effectively mitigate the investment risk profile.

Preferred Investment Horizons

Long-term investment horizons were favored by respondents, with 61% of respondents stating a preference for a seven-or-more-year time frame. Noting this result, a satisfactory financial return on new BC investment may not be reflected until vegetation is established and carbon sequestration occurs. This results in an up-front capital burden for BC investors that may erode potential returns if unmanaged.

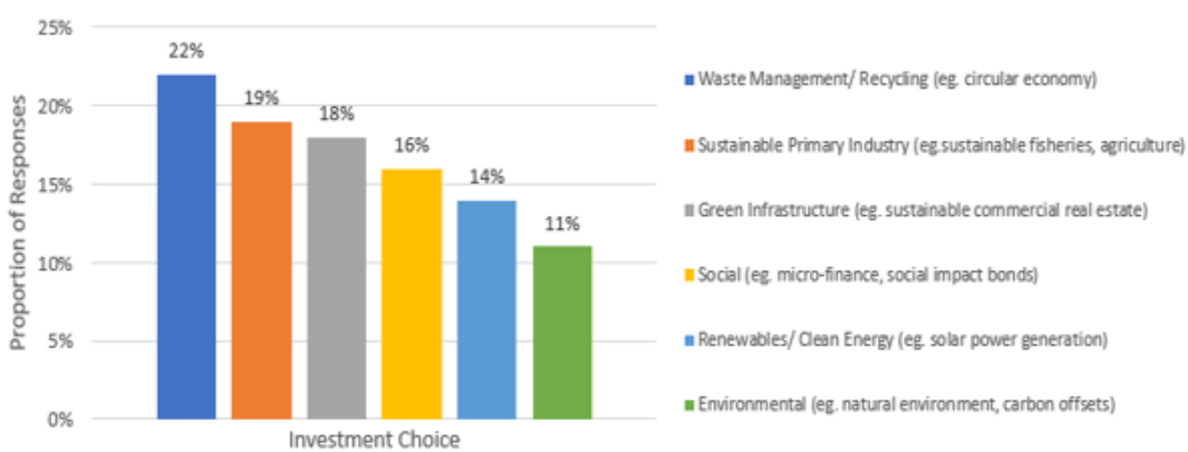
Careful consideration for BC ecosystem composition is advisable. Analysis of associated costs for 235 marine restoration studies indicated that mangroves had the lowest cost per hectare, while seagrass had the highest cost per hectare as of 2010 (Bayraktarov et al. 2016). The same study found that seagrass had the lowest restoration success rate (38%) and salt marshes the highest success rate (65%) (Bayraktarov et al. 2016). Based on Bayraktarov's analysis, seagrass represents the weakest investment option because of its high costs and low project success rate.

Preferred Responsible Investments

To quantify private investor appetite, respondents were required to rank segmented investment preferences via the "drag-and-drop" ranking tool in the Qualtrics© survey platform. The investment preference list was not intended to be exhaustive but to synthesize established RI sectors. The six choices available in ranking order were: (i) socially responsible investments (e.g., microfinance, social impact bonds); (ii) environmentally responsible investments (e.g., carbon-offset projects); (iii) green infrastructure (e.g., sustainable commercial real estate); (iv) renewable and clean energy (e.g., solar power generation); (v) sustainable primary industry (e.g., sustainable fisheries or agriculture); and (vi) waste management and recycling. To improve the statistical validity of the results, respondents were asked to assume a single investment focus per choice and rank accordingly.

Based on the responses, waste management and recycling was the most preferred investment option while environmentally responsible investments was the least preferred option (Figure 4). An inference that can be drawn from these results is the preference of private investors for established investment sectors with prevailing commercial fundamentals, such as waste management and recycling, sustainable primary industry, and green infrastructure, which were the top three categories respondents chose (Figure 4). An outlier based on the survey results was the low ranking of renewable and clean energy, which was the second-lowest investment preference. Since a majority of respondents were based in Australia, this result is likely a reflection of indecision in energy and emissions policy during the survey period.

Figure 4. Preferred Investment Choices



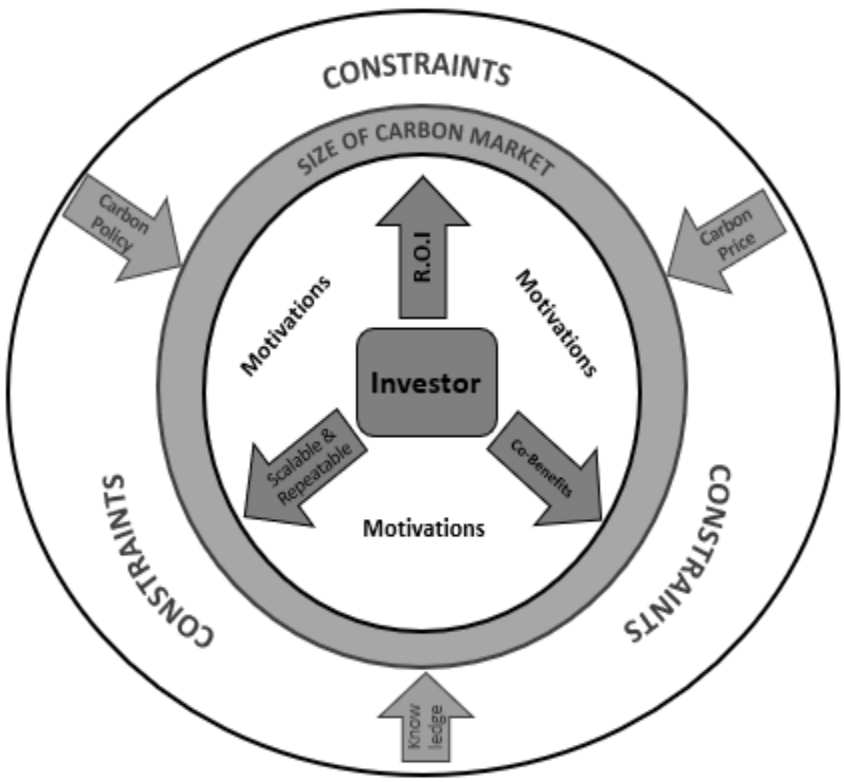
Source: *Author, 2019.*

From a BC investment perspective, the low ranking of environmentally themed investments is of concern. Again, the importance of linking the broader social and economic co-benefits of BC resources to viable investment outcomes may serve to offset this low ranking.

Conceptual Framework for Private Blue Carbon Investment

The development of a private investment framework for BC is no simple task but clear pathways need to emerge to guide stakeholders. Using the results of this study, we developed a conceptual framework aimed at guiding stakeholder dialogue (Figure 5). The conceptual framework focuses on the top three carbon market constraints identified by respondents (i.e., carbon policy, carbon price, and limited investor knowledge of carbon markets). Conversely motivations for future private BC investment identified are return on investment (ROI), investment scalability and repeatability, and co-benefits. By focusing on these key factors, stakeholders can better determine where to pitch BC for private investment.

Figure 5. Conceptual Model of Blue Carbon Market Constraints and Motivations



Source: *Author, 2019.*

Limitations and Recommendations for Future Research

With 44 completed responses, the sample size of the survey was relatively small. Countering this is the caliber of respondents and their influence in the RI landscape. Despite the anonymous nature of the survey, various respondents chose to contact the authors directly following survey completion, including respondents representing prominent institutions on the Australian investment landscape. Among the organizations respondents worked for are some of the biggest professional services networks in the world (offering audit and assurance services, management consulting, and advisory, actuarial, and corporate finance services); Australian ethical investment firms; the country's largest commercial and investment banks; government-owned superannuation corporations; and major philanthropic groups.

Geographic coverage of respondents was also a limiting factor. Although this research sought to include global investment perspectives, only four respondents outside Australia completed the survey. While these global insights are valuable, the representation of Australian respondents (90% of completed surveys) heavily contextualizes research findings to an Australian perspective. Further sectoral segmentation would benefit future research. For instance it would be misleading to infer that all for-profit organizations operate with the same investment motives across sectors.

Surveys represent a snapshot in time and can be influenced by prevailing economic and government policy discussions, impacting respondent sentiment. Two significant factors potentially impacting this study were the federal emissions policy debate in Australia regarding the National Energy Guarantee. Additionally, The Global Climate Action Summit held in late September 2018 garnered significant private investor interest, along with commitments from institutional investment actors to invest to meet climate targets. As the summit was held after the survey deadline, some of this positive investor sentiment may not have been captured.

Conclusions

There is an increasing interest in RI as mainstream, private investors become more acquainted with the fundamentals of the field. At present, however, less volatile and established commercial investments hold greater appeal. Promising eco-centric investment signals are emerging, including new green-bond methodologies under development for ecosystem conservation and restoration (Huwyler 2014), both aligning with BC resources.

Closer alignment with global-scale initiatives, particularly the ubiquitous SDGs, may also prove beneficial to BC stakeholders in addressing the familiarity deficit identified by our research. These more established initiatives already have the benefits of scale and discursive influence while also aligning with investor metrics such as impact.

Our study results and conceptual framework may guide more informed interactions with private investors by BC stakeholders. Such interactions will be essential in addressing the BC knowledge gap identified among respondents. Our study also highlights the importance of presenting private investors with quantifiable co-benefits underpinned by credible financial and economic returns.

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Biographies

Ryan Cook is a Master of Environment candidate at the University of Melbourne, Australia. His studies have focused on corporate social responsibility (CSR) in relation to responsible business and investment practices, and in particular on the impact and role responsible investment can play in transitioning to a low-carbon economy. In addition to his current studies, Ryan is also qualified with a Bachelor of Agribusiness (Curtin University, Australia) and a Diploma of Sustainability (Central Institute of Technology, Australia). Before commencing his current master's studies, Ryan was employed within the Australian financial services sector in senior analytical and advisory roles.

Dr. Sebastian Thomas is director of the Sustainability Science Lab (sustainabilitysciencelab.com) at the University of Melbourne, and works closely with business, government, and civil society organizations on issues of climate change, sustainability innovation, and socio-technical transition. His research examines the social–ecological dynamics of local initiatives in the context of wider policy and market frameworks, and he is particularly interested in environmental approaches to building resilient and healthy communities.

A Comment on "Responsible Investment in Blue Carbon Resources: 'Constraints and Potential Motivations for Attracting Private Capital Investment in Blue Carbon Resources'"

William Page, Senior Portfolio Manager

Essex Global Environmental Opportunities Strategy (GEOS)

For background: I manage a global, listed-equity clean technology strategy, GEOS, and have been focused on thematic investing to climate solutions for over 10 years, after 20 years of ESG-focused investing. I found the paper by Ryan Cook quite interesting and insightful, as I have never heard of Blue Carbon (BC). Therein may lie the challenge. BC may be too esoteric—too much at the periphery of environmental investing—to garner asset owner attention. This should not be the case, however, since Mr. Cook's convincing thesis supports BC as an asset class, given the impressive carbon sink richness of the coasts when compared to more terrestrial carbon sink methods.

Paper and Methodology

In the discussion of responsible investment, the reference to ESG NGO signatories can be misleading, because ESG assets under management/advisement generally include negative-screened ESG assets, or listed-equity sustainability funds. These assets tend to be large-cap and listed-equity in nature, and tend to track ESG investment strategies that hold companies exhibiting strong ESG corporate behavior, and not companies with services or technologies that are solving environmental and climate degradation. The latter case is thematic and solutions-oriented—true sustainable solutions that can include clean tech and direct environmental solutions such as BC.

I believe the ESG industry needs to place more emphasis on moving the case for climate change solutions well beyond ESG behavior to direct investment in solutions. There is a strong degree of cognitive dissonance among asset owners and their advisors in this regard. Owners and advisors hesitate to invest in solution-oriented environmental investment offerings that do not align well with historical, classical methodologies such as asset-allocation assessment. I believe this is the primary reason that BC did not resonate as a prioritized investment strategy in Mr. Cook's study. This issue is reflected in the reference to the UN Principles of Responsible Investment (PRI). While asset owners and their advisors are joining NGO initiatives such as the UN PRI, little is being done to truly move the needle beyond ESG risk assessment to investing in intentional climate solutions. Thus, I believe the asset values of the signatories of efforts such as the UN PRI misrepresent asset owner intent in truly solving and abating climate change.

As far as the methodology of this study is concerned, I believe the market research effort was strong and rigorous. I did wonder how the sample population of Australian respondents was determined and uncovered. As the author mentioned, a broader sample outside of Australia may have led to greater confidence, yet I believe it would not generally change the conclusion since Australia is an established, mature capital market, with long-standing environmental investment disciplines.

I was struck by the 93% of respondents who reported having invested in the past in an environmentally themed initiative. An interesting follow-up would be getting more detail on the nature of these investments, and why the asset owners were comfortable with such investments. What were the terms for investment, and the nature of the asset classes? Was it merely ESG investing, or more solutions-oriented? Another interesting perspective would be describing the social media context of BC. A quick look on Twitter showed little BC content, which is consistent with the study's conclusions that BC awareness is very limited.

Recommendations

It is clear from this thesis that blue carbon is a relevant solution for climate change, and investors with interest in climate should review BC investment options. An effort to raise awareness of BC, from academia to the investment industry, is necessary in order to create the case for investment and design investment options and offerings.

I would recommend involving NGOs and affinity groups to drive awareness and education in BC. For a good example of successful environmental campaigns, look to the ocean plastic efforts of the past few years. In very little time, strong public relations and media content has centered worldwide awareness and action on ocean plastics. While BC is more esoteric and less tangible, a solid and simple campaign centered on BC as a sequestration solution would be effective. Through public information, the parallels of BC should be drawn to climate change, carbon abatement, and seacoast storm mitigation and coastal climate adaptation. Research and messaging of the ancillary benefits of BC could catalyze asset owner interest. I would also recommend alignment with NGOs and academic institutions that have interest in climate change mitigation and coastal preservation. One such effort that comes to mind is the SSPEED Center at Rice University in Houston (https://www.sspeed.rice.edu/).

As an educational campaign for BC is undertaken, a simple scientific description should include why BC is more effective than terrestrial plants at sequestering carbon. A media effort coupled with NGO involvement speaking to the benefits of BC should then be supplemented with investor offerings in direct mitigation projects, with aggregation in mind for inclusion in green bond and impact offerings.

Thank you for the opportunity to learn about an important and evolving carbon-abatement method.

Development of a Quantitative Model for the Top-Down Estimation of Greenhouse Gas Emissions from Transportation and Distribution Activities of Companies' Supply Chains

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Abstract

Assessing and managing companies' climate-change-related investment impacts and risks require a detailed understanding of their greenhouse gas (GHG) emissions. Yet for many companies, the dominant source of GHG emissions is indirect emissions that appear outside the company's main operating space (Hertwich and Wood 2018; EIT Climate-KIC 2018b). Of the 15 supply-chain emission categories defined by the Greenhouse Gas (GHG) Protocol, this paper focuses on companies' upstream and downstream transportation and distribution supply chains (Categories 4 and 9). Here, a quantitative model has been developed to estimate the GHG emissions from these categories.

The model has been developed with a company agnostic top-down approach, and is based on validated secondary data. Upstream and downstream transportation and distribution GHG emissions data reported from the Carbon Disclosure Project (CDP) are applied as benchmark data for calibration of the model.

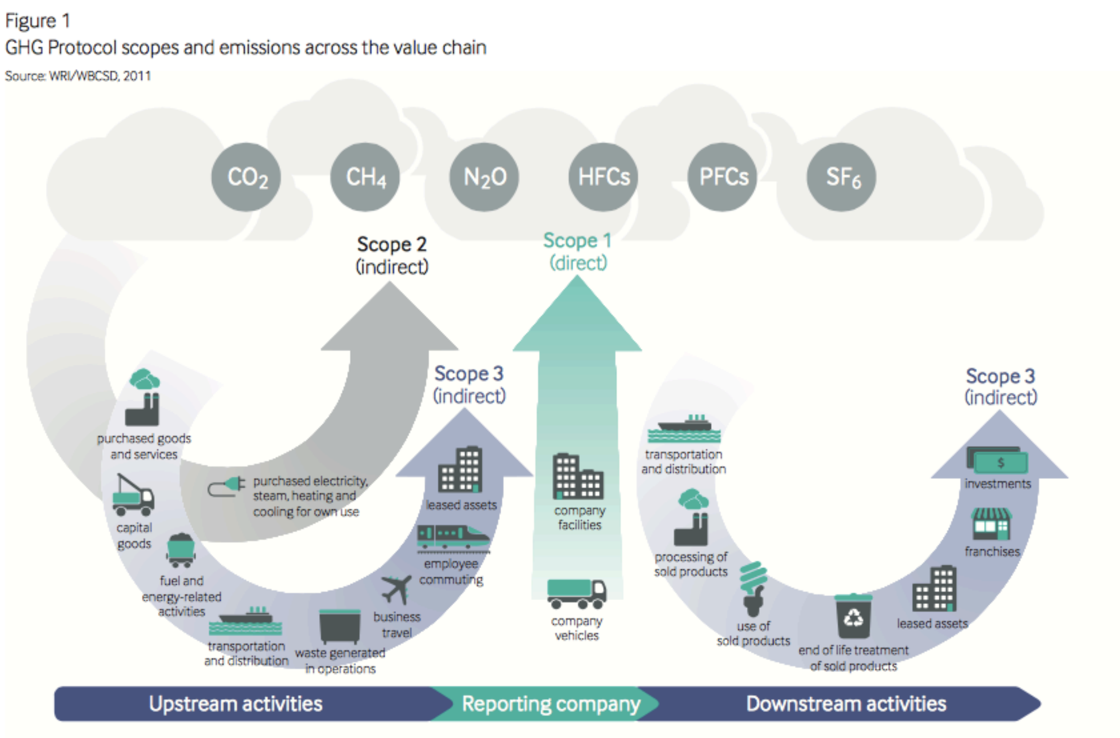
The results of the calculations of the model show a moderate positive linear correlation between calculated and reported Category 4 and Category 9 emissions. The model gives the potential user comparable and transparent data on transportation- and distribution-related GHG emissions currently occurring from 22,000 companies' supply chains. This information can be applied in assessing climate-change-related risks and impacts of investments. Additionally, the model contributes a scalable alternative to the time-consuming bottom-up life-cycle assessment (LCA) or the application of the inadequate CDP-reported data for supply-chain emission estimation.

Development of a Quantitative Model for the Top-Down Estimation of Greenhouse Gas Emissions from Transportation and Distribution Activities of Companies' Supply Chains

The already acknowledged worldwide implications of climate change have correspondingly begun to affect the financial industry. Efforts to address climate change—such as the introduction of mitigation policies (for example, carbon pricing; European Union 2015); demands for GHG emission reductions in industries (for example, National Determined Contributions; UNFCCC 2018); and shifts in consumer demands—are starting to have an impact on the valuation of companies (Ottman 2011; Hertwich and Wood 2018). Consequently, these efforts are resulting in potential investment risks to companies (McCarthy et al. 2001; Bracking 2015; Wolfrom 2015). Yet, financial models and tools that contain structured and systematically organized climate impact and risk information to redirect investments into companies with low climate-change-related investment risks and impacts are still scarce (GHG Protocol 2011; EIT Climate-KIC 2018a). Due to this lack of information derived from companies on GHG emissions, there is a strong need to establish quantitative models to estimate the GHG emissions occurring in the supply chains of companies. Estimating the emissions on a top-down level can give investors access to comparable and transparent data on emissions occurring in companies' supply chains.

Currently, most regulatory climate risk and opportunity assessments on an enterprise level depend on direct and indirect GHG emissions that occur within the company's operational perimeter. These are called Scope 1 and Scope 2 GHG emissions by the GHG Protocol (Figure 1; 2011). They are typically calculated by applying a time-consuming and expensive bottom-up life-cycle analysis (LCA; Jacquemin 2012). However, research shows that upstream and downstream emissions appearing outside the company's main operating space, the so-called Scope 3 GHG emissions, are the dominant source of GHG emissions for most economic activities (Downie and Stubbs 2013; Zah 2015).

Figure 1: Scopes and Emissions*



Source: *GHG Protocol. 2011, 31.*

**Scope 1, Direct emissions; Scope 2, indirect emissions by electricity purchase; Scope 3, indirect emissions via the supply chain of a company, as defined by the GHG Protocol (2011).*

Because of this emphasis on emissions within operations, many company investments are based on limited and potentially misleading information that only partially reflects the size of the carbon footprint and climate risks or opportunities of a company (Hertwich and Wood 2018).

Significant contributors to the supply-chain GHG emissions are activities related to transportation and distribution, which cover more than 10% of total supply-chain emissions (CDP 2018). Transportation services are energy intensive, especially as oil is being consumed and combusted, resulting in high GHG emissions (Weidema 2013).

Transportation as a whole accounts for more than 20% of the world's GHG emissions, and freight transportation contributes to a substantial degree (Auvinen 2014). Transportation-related emissions by 2030 are expected to grow by 50%, and by 100% by 2050, compared to their 2007 level (Craig, Blanco, and Sheffi 2013). Because transportation is already contributing to a company's GHG emissions, and is expected to contribute increasingly, it is essential to understand the emissions from this source (Stadler 2018).

Current models or research projects estimating companies' supply-chain emissions are limited (GHG Protocol 2011). The state-of-the-art research and models for estimating GHG emissions from freight transportation can only allocate the emissions on sectoral or national level (Cadarso et al. 2010; Andersen et al. 2010; Cristea et al. 2012; Auvinen et al. 2014). Using these models to derive information on companies' GHG emissions is difficult, because the models are not linked to company-specific values or information.

This developed model can estimate transportation- and distribution-related emissions from companies' supply chains. The emissions are assigned to the companies paying for or causing the transportation activity by linking the extent of emissions to company revenue data. Currently the method is applicable to 22,000 publicly traded companies and scalable to even more.

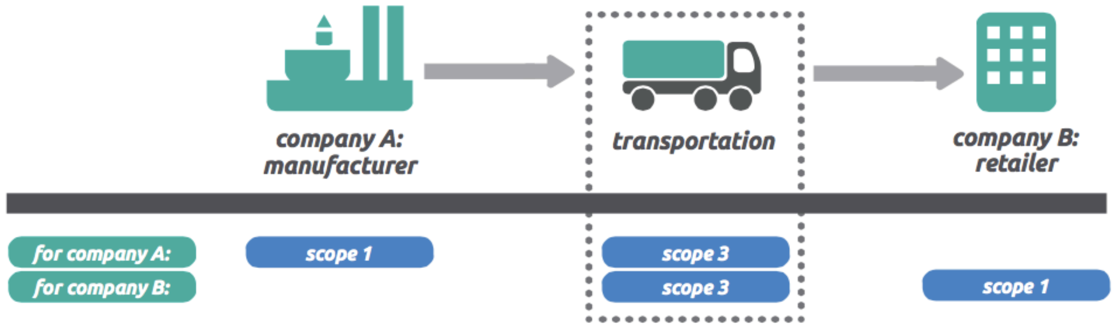
Methodology

The model is built with a distance-based approach, recommended by the GHG Protocol (2013). This approach includes activity data for transportation and incorporates mass, distance, mode of transportation and emission factors for the transportation modes. According to the GHG Protocol, the definitions of Categories 4 and 9 are

> ***Category 4***
>
> *Transportation and distribution of products purchased by the reporting company in the reporting year between a company's tier 1 suppliers and its own operations (in vehicles and facilities not owned or controlled by the reporting company).* (GHG Protocol 2013, 8)
>
> ***Category 9***
>
> *Transportation and distribution of products sold by the reporting company in the reporting year between the reporting company's operations and the consumer (if not paid for by the reporting company), including retail and storage (in vehicles and facilities not owned or controlled by the reporting company).* (GHG Protocol 2013, 9)

Companies A and B illustrate how the categories differ. The emissions occurring for company B are the upstream transportation and distribution emissions, and for company A, they are the downstream transportation and distribution emissions (Figure 2).

Figure 2: Distinguishing the Upstream and Downstream Transportation and Distribution Emissions



Source: *GHG Protocol. 2011, 108.*

Developing a model with a top-down approach requires a parent methodology, where companies are grouped into sectors. The model has therefore been developed on a company agnostic approach. The model distinguishes between transportation patterns in different sectors. The sectors are used as a proxy for how a specific company within a certain sector performs regarding transportation activities. Companies are hence mainly distinguished by which sectors they operate in, and the annual revenue created within specific sectors and specific countries.

Data Sources

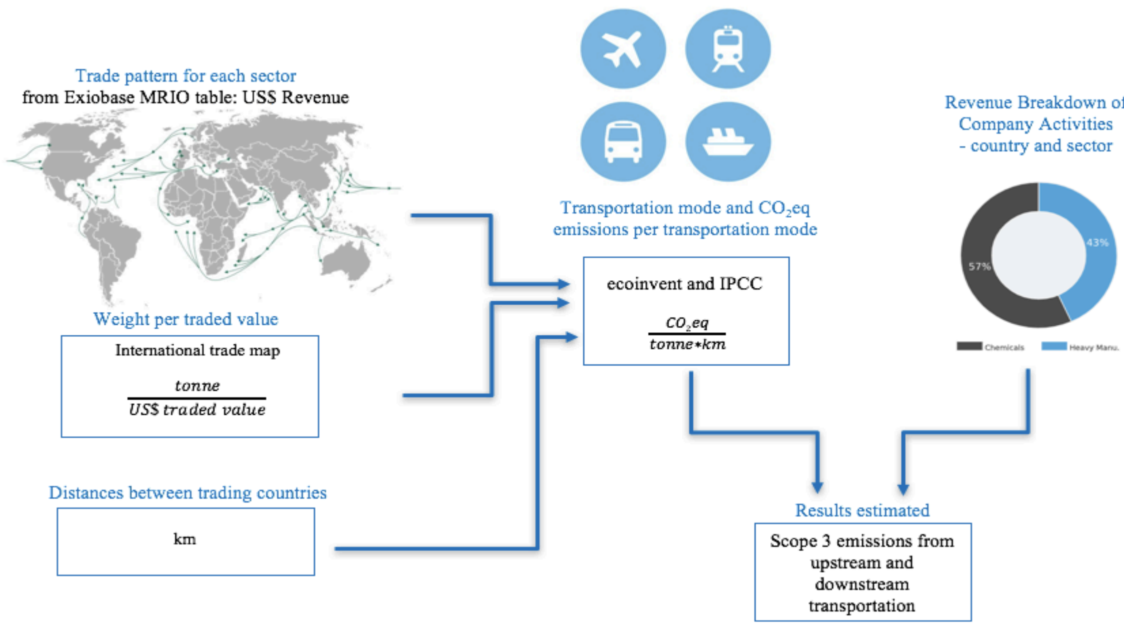
Trade data is extracted from the Exiobase Multiregional (MRIO) database, which contains a multiregional input–output table with intra- and intersectoral and intra- and intercountry trade values. Here, revenue and traded value of the traded products have been found, extracted, and linked to weight data (Tukker 2013). Data on "weight-per-traded-value" has been extracted from the *International Trade Map* (ITC 2018).

The distance between the represented countries has been calculated as follows: The capital or main economic center has been used as the representative start- and end-point for the transportation activity (Mayer and Zignago 2011; Bertoli, Goujon, and Santoni 2016).

Data on the most-used transportation mode (including trucking, rail, marine shipping, flight, and pipeline) for different sectors has been extracted from the ecoinvent transportation database. The emission factor in tonnes CO_2eq/tonne*km per transportation mode has been extracted from IPCC's emission factor database (Wernet 2016; Borken-Kleefeld 2012; IPCC 2013).

This emission data from transportation activities per sector has been matched to revenue breakdown of company activities per country and sector. The data is extracted from *Carbon Delta* (2018; Factset 2018). With the data, it has been possible to calculate and estimate GHG emissions for the 4 and 9 Scope 3 categories from companies' supply chains (Figure 3).

Figure 3: The Methodology of the Development of the Model *(programmed in Python)*



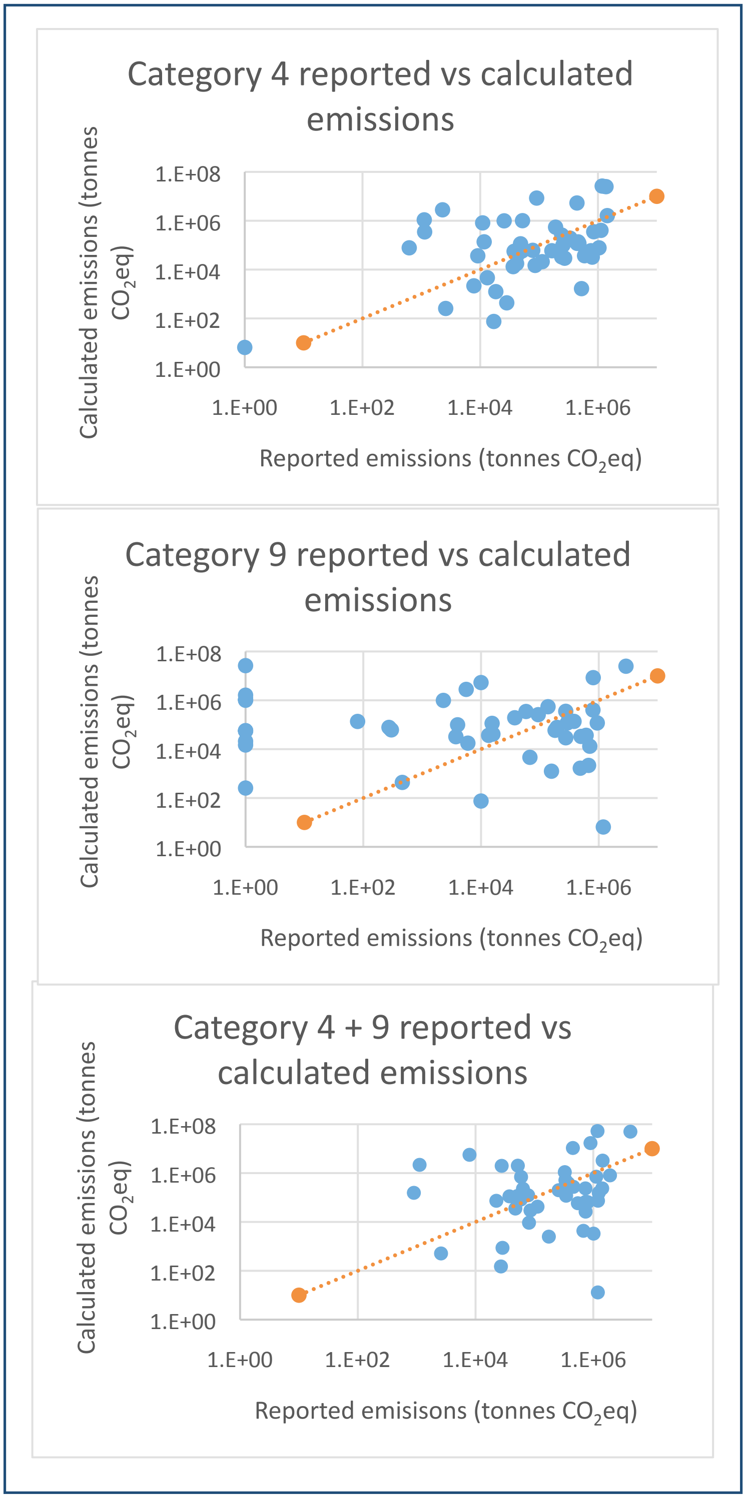
Source: *Developed by author, 2019.*

The calculated emissions have been compared to the Categories 4 and 9 emission data from 70 companies reporting to the CDP (2018).

Results

The correlation between the calculated emissions and the CDP-reported emissions can be seen in Figure 4. Here, the modeled emissions are validated against CDP-reported emissions, and mapped in a logarithmic scale. The emissions have been grouped, respectively, into Category 4, Category 9, and Category 4 + 9. The calculated correlation coefficient for Category 4 is 0.5, for Category 9, 0.5, and for Category 4 and 9 combined, 0.6. Consequently, there is a moderate positive-linear relation between the reported and the calculated emissions. The model both underestimates and overestimates the emissions for the two categories and the combined categories. Here, the mapped dots (representing the calculated versus reported emissions) are distributed both over and under the x=y line. The x=y line represents the perfectly fitting correlation line. Companies that could not be assigned emissions due to lack of data are not mapped in the graph.

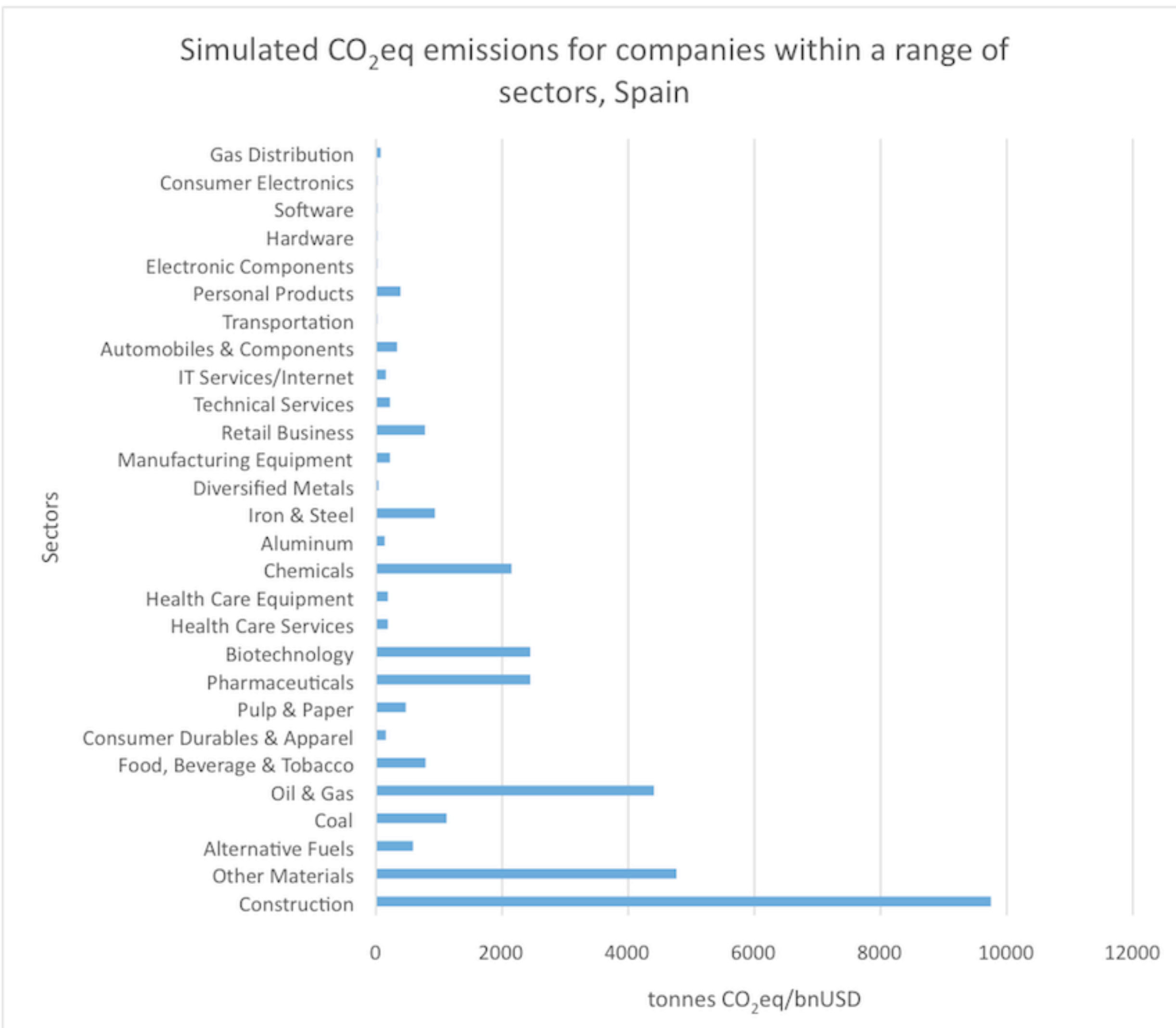
Figure 4: Modeled GHG Emissions Validated against CDP-Reported Emissions in a Logarithmic Scale Respectively for Category 4, Category 9, and Category 4 + 9 *(The orange line represents the x=y and the small blue line represents a linear trend line.)*



Source: *Developed by author, 2019.*

By conducting a t-test, the p-value is 0.10 for Category 4, 0.07 for Category 9, and 0.20 for Category 4 and 9 combined. Under the null hypothesis, assuming that the two data samples are similar (having the same mean) and significance level of alpha = 0.05, the outcome of the t-test (p-value > 0.05) indicates that I cannot reject the null hypothesis. The observed difference between the samples means (outcome of the two sample t-tests) is not convincing enough to say that the means of the two samples differ significantly. The range of simulated companies operating in the different sectors demonstrates how the developed model differentiates GHG emissions among companies operating within different sectors (Figure 5). Here, Spain has been chosen as an illustration. GHG emissions are reported in tonnes CO_2eq/bnUSD.

Figure 5: Simulated Upstream and Downstream CO_2eq Emissions for Companies within a Range of Sectors in Spain *(A number of companies within the tertiary industry have an emission factor of 0 or very low and are not presented in this table.)*



Source: *Developed by author, 2019.*

The sectors with the highest GHG emissions are typically the sectors transporting heavy products and goods (for example "Construction" and "Oil and Gas"), or products and goods that are typically transported with a transportation mode, which has a high GHG emission factor (for example, flight). These sectors are typically "Chemicals," "Biotechnology" and "Pharmaceuticals." The observed tendencies in sectors with high GHG emissions correlates with the assumptions suggested by McKinnon (2007) and by Cadarso et al. (2010).

Discussion

The model builds on a combination of different databases, where each of the databases are used as a proxy for how different countries and sectors trade internally, transport their goods, how far, and with what transportation mode.

Application of Secondary Databases for the Development of the Model

Adding up assumptions and uncertainties from many different data sources led to an accumulation of uncertainty in the model. As the sector segregation does not match across all applied databases, additional uncertainty is added to the model output.

Moreover, applying secondary databases and using them in a company-agnostic way yields average GHG emissions for different sectors. Consequently, only their annual revenue will distinguish companies operating in the same sector. This means that for companies with comparably high or low transportation activities within the sector, the model will under- or overestimate their GHG emissions, respectively.

Furthermore, the secondary data cannot distinguish whether individual companies are mainly trading locally or globally. The modeling does not take into account whether companies within the same sector are trading and thus transporting their goods differently.

Linking Emissions to Revenue Data

The assumption that emissions from transportation activities relate to annual revenue is supported by the fact that companies with a high revenue most likely have a high business activity and hence, more products or goods are sold and being transported (Andersen et al. 2010; ITF 2015). However, this assumption is not generally valid for companies within the tertiary industry, where revenue is often created from immaterial products. This includes, for example, companies within the financial, telecommunication, consultancy, or education sectors. It can also be difficult to group companies unambiguously.

The International Trade Map and the ecoinvent database (ITC 2018;Wernet 2016) do not contain data for all sectors represented in *Carbon Delta* and Exiobase. This is the case for several sectors within the tertiary industry, such as the financial sector and service sectors. It has therefore not been possible to model transportation-related GHG emissions for many companies within the tertiary industry.

For future modeling, an estimation of emissions for sectors within the tertiary industry could be applied to assign emissions for sectors where data has not been available. To this end, examining emissions in a bottom-up approach from a sample of companies within these missing sectors could help to quantify possible emissions.

Scope 3 versus Scope 1 Emissions from Companies' Transportation Activities

The model developed here builds on the assumption that transport activities related to one company are performed by another company. This means that all the trade and related transportation data extracted from the Exiobase database have been assigned to Scope 3 emissions.

Companies could potentially own their vehicle operation systems (VOS), where the emissions from these VOS would count as Scope 1 emissions. It was impossible to assess which companies own their transportation vehicles. Yet, as freight transportation for companies is—to a large extent—managed by transportation service companies (ITF 2015), the assumption is potentially plausible. The assumption can lead to a small overestimation of GHG emissions from transportation and distribution activities for some specific companies.

In order to avoid this overestimation for future modeling purposes, an examination of sectors where the companies' ownership of their transportation vehicles is more common could be made, and afterwards integrated in the model.

Applying Several Databases with Different Assumptions to Databases from Different Years

The applied databases are generally from different years in the 2010s, and all are associated with assumptions and/or uncertainties. These factors can skew data output, resulting in both potential under- and overestimations. But because of the awareness that assumptions and uncertainties can lead to this skewed data output, the scope of the thesis has not been to calculate the exact emissions, but rather to quantify possible GHG emissions for companies.

It has not been possible to find databases that were developed from the exact same years, with the result that their base years vary from 2011 to 2018. But the newest data from the different chosen data sources has always been applied. Therefore, the applied data sources express different tendencies on trade and transportation patterns when compared to the actual transportation pattern in 2017 (the base year of the CDP database to which the results of the model have been compared). For more accurate calculations in future models, updated databases, preferably from the same years, should be applied once they are available.

Comparing the Data with Benchmark Data from CDP

As part of the model development, modeled emissions are validated against reported CDP emissions. There is a moderate positive correlation coefficient (+0,6) between the calculated and reported data. The fact that these two datasets are not correlating to a high degree (>0,9) can partly be explained by the several previously mentioned reasons and by the fact that the CDP data is also associated with errors (Stanny 2018; Sullivan 2009). There is a chance that my model potentially provides more accurate emissions data than the reported emissions. The CDP-reported data has nevertheless been used as benchmark data, because it is the only accessible data on Scope 3, Categories 4 and 9 emissions.

In order to investigate whether the data is representative, a sensitivity analysis could advantageously be applied for future research. Such an analysis could be applied to predict the outcome of a decision based on a certain range of variables. By applying this analysis, it can be determined if and how changes in one variable will affect the data outcome. This could help to identify which parameters of the model have the biggest decisive force, and clarify in which parts of the model extra attention should be given regarding the quality of the applied data.

Conclusion

This paper is written as a result of the development and contribution of a quantitative model to estimate indirect GHG emissions of companies in a top-down approach. Of the 15 supply-chain categories defined by the GHG Protocol, the developed model contains the two: Category 4: Upstream Transportation and Distribution, and Category 9: Downstream Transportation and Distribution.

The model is built on a company agnostic top-down approach based on validated secondary data. The results of the calculations show a moderate positive linear correlation between calculated and reported Scope 3 emissions.

The model can, combined with the modeling of the other 13 categories defined by the GHG Protocol (2011a; 2018a), give the full overview of possible GHG emissions occurring in 22,000 companies' supply chains. This can give investors and asset managers access to comparable and transparent data on probable emissions occurring from these companies' supply chains. This data can thus improve investors' assessments of climate-change-related risks, enabling them to invest in the companies with lower GHG emissions and thereby reduce the risk of financial losses.

Moreover, with this project, a new methodology is proposed for how emissions from companies' supply-chain transportation and distribution can be calculated in a scalable, top-down approach. This is in contrast to current state-of-the-art models that can only estimate and allocate freight transportation GHG emissions on a sectoral or national level. In addition, the model gives a transparent and scalable alternative to the current CDP database, where data is associated with errors, and to the bottom-up LCA approach, which is time-consuming and difficult to scale.

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Biography

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Some Statistical Considerations for Assessing Model Value when Estimating Greenhouse Gas Emissions

A Comment on "Development of a Quantitative Model for the Top-Down Estimation of Greenhouse Gas Emissions from Transportation and Distribution Activities of Companies' Supply Chains"

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To quantify a company's full greenhouse gas (GHG) emissions, life cycle analysis represents a valuable standard and active area of research (Reijnders, 2012). Clearly, one needs to consider the full path from extraction through manufacture, transportation, use, and disposal to tease out the fixed but unknown proportion of GHG emissions attributable to any particular company or product. The degree to which a life cycle procedure correctly computes the "true" GHG emissions of a product or company is always an important debate, but suppose one assumes a life cycle analysis is essentially correct, but too expensive or burdensome to conduct for all companies in some research setting. How should one evaluate the value of other estimates of GHG emissions that might be cheaper and easier to produce?

The preceding paper by Kjaer is an effort to develop such a model. However, the effort to do so faces some substantial challenges. Necessary -- but insufficient -- is an evaluation of the prediction accuracy by using a benchmark set of cases for which GHG emissions are known and can be compared to predictions. What is needed beyond this is (1) an assessment of underlying sample data themselves, and (2) statistical considerations of the quantitative methods themselves.

Assume we have: (1) a set of n observations (which could be companies, products, etc.) for which we wish to estimate total GHG emissions; (2) actual benchmark values of GHG emissions obtained from life cycle analysis which we call y_i, $i=1, \ldots, n$; (3) proxy data on each company x_i, $i=1, \ldots, n$; and (4) estimated GHG emissions $\hat{y}_i$, $i=1, \ldots, n$ which are produced from some statistical procedure applied to the proxy data. Whether or not the prediction procedure is of any value is a function of the prediction errors, which are the observed values minus predicted values $y_i - \hat{y}_i$, $i=1, \ldots, n$. Minimizing some sensible function of these errors such as the mean squared error (MSE) is often the basis for what we call the "best" model. Prior to this stage, however, are considerations of the data and methods themselves.

Is the GHG estimation procedure intended to be applied widely across a larger population, but demonstrated only on a smaller sample? If so, is the sample representative of the full population, or might it be a *convenience sample* -- easily obtained but ill-suited to stand in for the full population? The degree to which any value of the procedure extends to other samples depends precisely on the answer to this question.

Moving to the true benchmark GHG emissions y_i and proxy data x_i, one must consider if either *explanation* or *extrapolation* are also goals in building the quantitative model. Explanation allows for the meaningful interpretation of model parameters, and (loosely speaking) is the ability to explain to a person unfamiliar with building quantitative models why the model arrives at certain conclusions or predictions. Put another way, explanation is the opposite of so-called *black box* techniques, which produce predictions but often in an opaque manner. Extrapolation allows the quantitative model to be applied to new proxy data outside the range of the observed x_i, $i=1, ..., n$. A linear model (Faraway 2016) often scores highly on explanation and can score highly on extrapolation in some cases, whereas a tree or random forest (James et. al. 2013) often scores less highly on both counts. It is even possible that the model which scores highest for prediction accuracy has essentially no ability to be explained or extrapolated. Assessing predictive accuracy says very little about the value of a quantitative model for explanation or extrapolation.

Turning now to assessing predictive accuracy directly, a guiding question must be if errors in overestimation and underestimation are to be treated equally. There is the practical question based on how the GHG predictions are being used, but also the statistical question of how the model is fit. Consider a log-transformation of GHG emissions $\log_{10}(y_i)$, often needed to combine small-scale and large-scale companies in the same analysis. Suppose a particular company has actual emissions of 10^4 tons of CO_2 equivalent, or 4 on a $\log_{10}$ scale. Overestimating this company on a log-transformed scale by 1 is equivalent to overestimating by 90,000 tons (5 - 4 on a log scale is 100,000 - 10,000 on the base scale); underestimating by 1 is equivalent to underestimating by 9,000 tons (3 – 4 on a log scale is 1,000 - 10,000 on the base scale). Symmetry in errors also underlies many of the usual metrics for assessing prediction accuracy, such as R-squared, mean squared prediction error, and mean absolute prediction error. This is all to say that even in applications for which errors have asymmetric practical consequences, a surprising number of statistical procedures default to fit the quantitative model by treating errors symmetrically.

In summary, the value of a quantitative model for estimating GHG emissions should be determined partly by the predictive performance of that model on a benchmarked sample, and also from considerations of the sample itself and the properties of the modeling technique that are known to hold across numerous samples. The present paper pursues a worthy goal, but further development will be needed to realize its full, intended benefits.

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ESG Risk Factors and Tail-Risk Mitigation

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Abstract

To date, a great body of research has agreed on the benefits of sustainable investing on firm performance; however, its effects on portfolio risk are still rather unclear. This article aims to reconcile the existing literature on the impact of sustainability-related information with portfolio tail-risk. When conducted not only at an E/S/G score level but also at a key issue level, the analysis enriches the existing literature on socially responsible investing. We propose a simple statistical methodology to identify the most-relevant sustainability-related information driving equity returns. Then, we compare the portfolio expected shortfall before and after the application of a tilt toward the sustainability-related information selected at the previous step. In this way, we assess whether relevant sustainability-related information carries benefits in terms of portfolio tail-risk mitigation. Results show that specific sustainability-related key issues explain the cross-sectional variance of equity returns—thus behaving as risk factors—and reduce portfolio tail risk. Most of the identified relevant ESG data are the same across the European and the U.S. equity markets. Nevertheless, their magnitudes and relative ranking within these markets are different, thus reflecting heterogeneities in terms of investors' profiles, as well as the legal and regulatory frameworks of Europe and the United States.

ESG Risk Factors and Tail-Risk Mitigation

Over the last decade, an increasing number of companies and investors have committed to the integration of Environmental, Social, and Governance (ESG) information in their investment policies and capital allocation processes. Even though the importance of ESG data has been widely recognized, the identification of the most- or least-material ESG information and its relative effects on firms' performance and risk is still an open debate.

Besides lacking a formal definition, the materiality of ESG key issues systematically varies both at a cross-sectional level (Eccles and Serafeim 2013) and over time, thus raising difficulties in the determination of an unambiguous and agreed-upon classification between material and immaterial information. To date, a great body of research has focused on the relationship between sustainable investing and firm performance; however, the impact of sustainable investing on portfolio risk has attracted less attention. Moreover, while there is a general agreement on the positive, or at least non-negative, effects of ESG investing on firm performance (Friede, Bush, and Bassen 2015; Khan, Serafeim, and Yoon 2016) and on the existence of a causality link among the two (Glassman, Potoski, and Callery 2017), evidence on the overall impact of ESG investing with respect to risk is still mixed. Even though a restriction of the available investment universe triggers a reduction in portfolio diversification (Renneboog, Horst, and Zhang 2008), *ceteris paribus* firms with higher ESG ratings seem to exhibit lower total (Lee and Faff 2009) and idiosyncratic (Hoepner 2010) risk.

Similarly, investment strategies based on ESG data carry benefits with respect to tracking error reduction (Davis, Balkissoon, and Heaps 2017) and tail-risk mitigation across both developed (Hoepner et al. 2018; Ilhan, Sautner, and Vilkov 2019) and emerging markets (Verheyden, Eccles, and Feiner 2016). Nevertheless, other studies have carried evidence about the lack of a causal relationship between ESG scores and risk reduction (Sassen, Hinze, and Hardeck 2015), or of a clear effect of ESG investing on the portfolio risk-adjusted performance (Oikonomou, Brooks, and Pavelin 2012).

This article aims at reconciling the existing literature on the role and the effects of ESG information on portfolio tail risk. The contribution of the research is twofold. First, we use a purely statistical methodology to assess the relevance of sustainability-related information. Letting the data speak for itself, we classify as relevant the ESG information that behaves as a priced risk factor, that is, ESG information that shows a persistent and significantly high explanatory power over the whole sample period. Second, by using key issue scores in addition to the combined ESG score and the Environmental, Social, and Governance pillar scores, this analysis is the first one investigating the risk mitigation effects of sustainability-related information at such a granular level. On a monthly frequency and over the sample period from January 2013 to December 2018, we regress each sustainability score on the monthly return of all stocks belonging to its relevant MSCI Index (either MSCI USA or MSCI Europe). After having ruled out possible collinearities with other traditional risk factors, we identify a subset of sustainability indicators behaving as risk factors. The tail-risk reduction capability is tested by comparing the change in the expected shortfall from the original reference MSCI index to that of an artificial portfolio obtained by tilting the reference index toward a specific sustainability indicator. For a selection of key issues, the tilted portfolio presents a lower tail risk, thus providing supportive evidence to the existence of tail-risk mitigation benefits of investing in specific sustainability-related factors.

In Section 1, we introduce the methodology used to identify the material sustainability key issues and to test the tail-risk mitigation hypothesis. Section 2 presents the dataset and its relevant characteristics, and in Section 3, we show the empirical results in terms of significance and risk reduction both for the European and for the U.S. equity markets. Section 4 presents our conclusions.

Methodology

In this section, we identify which sustainability-related information is relevant in the explanation of equity stock returns. The analysis is performed in the context of a fundamental factor model using a variety of descriptors, such as the ESG score, three pillar scores (Environmental, Social, and Governance) and 34 key issue scores (Table 1).

Table 1: List of MSCI Key Issues

List of Sustainability MSCI Key Issues	
Access to Commerce	Human Capital Development
Access to Finance	Climate Change Vulnerability
Access to Healthcare	Health & Demographic Risk
Anticompetitive Practices	Labor Management
Biodiversity & Land Use	Opportunities in Clean Technology
Business Ethics & Fraud	Opportunities in Green Building
Carbon Emissions	Opportunities in Nutrition & Health
Chemical Safety	Opportunities Renewable Energy
Controversial Sourcing	Packaging Material & Waste
Corporate Governance	Privacy & Data Security
Corruption & Instability	Production Carbon Footprint
Electronic Waste	Products Safety Quality
Energy Efficiency	Raw Material Sourcing
Financial Products Safety	Responsible Investment
Financial System Instability	Supply Chain Labor Standards
Financing Environmental Impact	Toxic Emissions & Waste
Health & Safety	Water Stress

Source: *Authors, 2019.*

To reduce the sensitivity of the factor model to the choice of the independent variables (key issues and style factors like value, size, etc.) and the potential collinearities among them, we have opted for a univariate regression model to explain the cross-section of stock returns.

For each month, a cross-sectional regression using a fundamental factor model is performed for both the European and the U.S. equities comprising the MSCI Europe and the MSCI U.S. Indexes. The exposure of stock *i* to factor *k* is defined as a linear function of a score:

$$RawExp_{i,k} = b_k \cdot (a_{k,S} + score_{i,k})$$

where $a_{k,S}$ and b_k must be such that:

$$\begin{cases} \sum_{i \in S} RawExp_{i,k} = 0 & \forall S \\ \frac{1}{N} \sum_{i=1}^{N} RawExp_{i,k}^{\;2} = 1 \end{cases}$$

where *N* is the total number of stocks and *S* identifies the sector.

By imposing a null sum of the raw exposures within each sector, the first constraint ensures sector-neutrality and sets $a_{k,S}$ to be equal to the average raw score per sector. By setting a unit variance of the raw exposures, the scale is also standardized. To exclude any bias linked to the potential collinearities with other style factors, the style-neutral exposures (SNE) are calculated via the following linear regression:

$$RawExp_{i,k} = SNE_{i,k} + \sum_{l=1}^{L} C_{k,l} \cdot StyleExp_{i,l}$$

where $StyleExp_{i,l}$ is the exposure to the traditional style factor *l*, with *l* = *dividend yield, earning variability, growth, leverage, momentum, profit, size, trade activity, value, and volatility*. Starting from the initial raw exposures, the style-neutral exposures

$SNE_{i,k}$ are estimated via ordinary least squares (OLS) as the intercept of the linear regression model. Next, the returns associated with each factor, $f_{t,k}$, are computed. In the setting of a factor model and a univariate regression, the return of each stock *i* can be expressed as:

$$r_{i,t} = SNE_{i,k} f_{t,k} + \varepsilon_{i,t,k}$$

where $f_{t,k}$ is the return of the factor *k* at time *t*, and $\varepsilon_{i,t,k}$ is the residual return. From a theoretical point of view, $SNE_{i,k}$ should also be time dependent; nevertheless, as exposures vary slowly and the time horizon is sufficiently short (monthly), it is reasonable to consider them constant and equal to their value at the beginning of the return period. Hence, the return of factor *k* at time *t* equals the return of a long-short portfolio which buys $SNE_{i,k}/N$ of the stock *i*,

$$f_{k,t} = \frac{1}{N}\sum_{i=1}^{N} SNE_{i,k}\, r_{i,t}$$

where *N* is the total number of stocks, and a positive/negative sign of $SNE_{i,k}$ indicates whether a position is long/short, respectively.

To evaluate the accuracy and the reliability of the factor regression, we rely on the adjusted R-squared[1] and the t-statistic metrics. We calculate the mean adjusted R-squared as the average of the adjusted R-squared over time (henceforth, we refer to this quantity as *explanatory power*) and we define as *significance* the percentage of times in which the absolute value of the t-statistic exceeds 1.645, the 95% quantile of the normal distribution. The explanatory power is used as a metric to classify the sustainability-related information: whenever it is larger than zero, a factor is deemed to be relevant.

Once the most-informative ESG data are identified, the last step of the analysis aims at testing the risk-reduction hypothesis of those at a portfolio level. The most-popular tail-risk metrics are the Value-at-Risk (VaR) and the Expected Shortfall (ES). As the latter

[1] Adjusted R-squared is preferred to the (simple) R-squared as it takes into account the size dependence of the sample, that is the stock coverage of the scores.

captures the severity of tail losses and is a sub-additive risk measure (unlike the VaR, it is a *coherent* risk measure), we choose the Expected Shortfall to measure portfolio tail risk. More precisely, we derive and compare the ES of the reference MSCI Index with that of the same MSCI Index tilted toward a higher factor exposure. For each relevant factor k, the tilt is performed by adding the factor portfolio to the initial reference MSCI Index. To assess whether the application of a factor k tilt mitigates tail risk, we introduce the Tail-Risk Mitigation (TRM) ratio:

$$TRM_k = \frac{ES(B+\gamma \cdot f_k) / \sigma(B+\gamma \cdot f_k)}{ES(B) / \sigma(B)}$$

where B denotes the reference MSCI Index return, f_k is the return of factor k, ES is the one month Expected Shortfall at 90% confidence level, $\sigma(\bullet)$ is the volatility of the profit and loss distribution of the argument, and γ is the magnitude of the factor tilt applied to the MSCI Index. Whenever TRM_k is lower than 1, factor k has mitigated the portfolio tail risk.

The Dataset

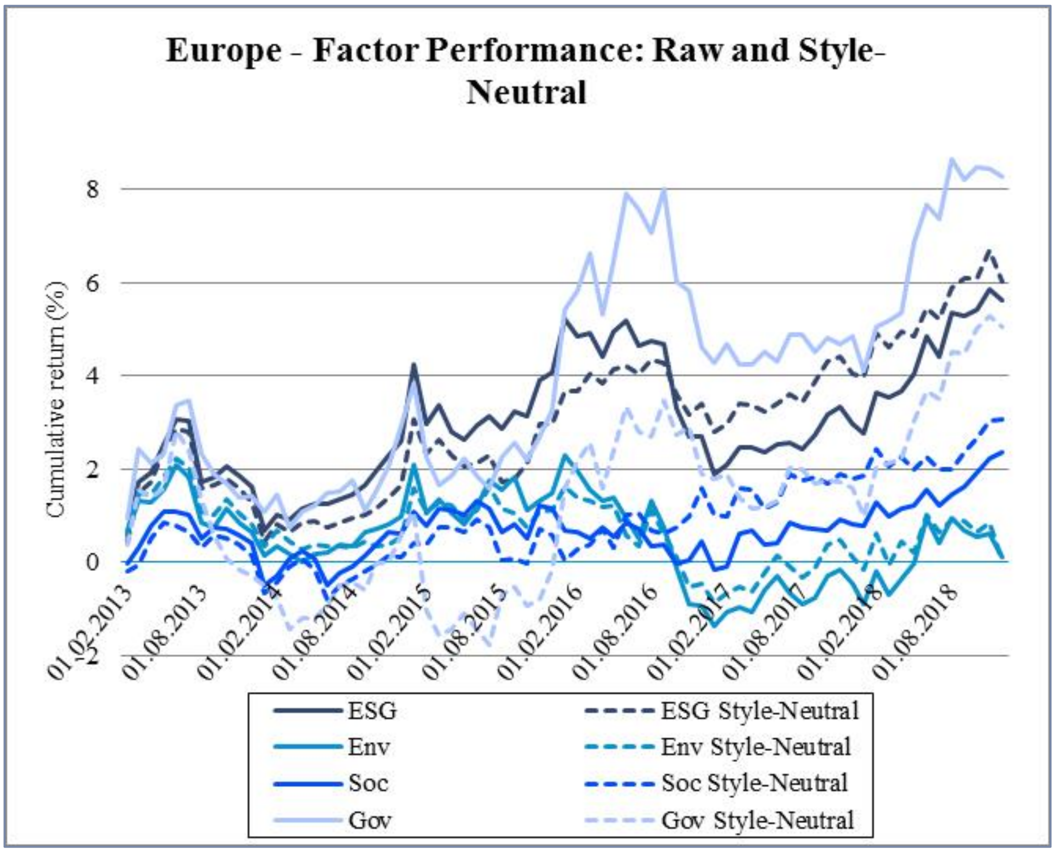
The sample period ranges from February 2013 to December 2018. The sample data include historical monthly equity returns, the time series of the monthly exposures of each company to the most-relevant style factors, and sustainability-related data. For all companies belonging to the MSCI Europe and MSCI U.S. Index, MSCI provides 71 monthly stock returns in local currency. For all European and U.S. companies in the sample, monthly exposures to style factors are obtained from the bank's risk system, which uses market standard definitions. For each company, sustainability-related information concerning the monthly ESG and the 34 key issue scores are sourced from MSCI ESG; whereas E/S/G pillar scores are delivered by Bank J. Safra Sarasin's internal model. Our study is primarily focused on Europe; nevertheless, the full analysis has been run for the U.S. equity market too.[2]

[2] Due to length constraints, some results for the United States have been omitted in the main body of the paper, but are available upon request.

Empirical Results

The methodology presented in section 1 is applied to the European and U.S. companies belonging to the MSCI Europe and MSCI U.S. Indexes. The cumulative factor returns are plotted both for the raw and style-neutral pillars and for the ESG scores in Europe (Figure 1). The style-neutralization has the strongest effect on the Governance pillar, whereas for the Environmental, Social, and ESG factors, its impact is not particularly relevant.

Figure 1: Cumulative Returns of Raw and Style-Neutral ESG and Pillar Factors Over the Period Feb. 2013–Dec. 2018 in Europe



Source: *Authors, 2019.*

We investigated the strength of the ESG, pillar, and key issue factors in explaining stock returns. For both the European and the U.S. equity markets, we looked at the significance and the explanatory power for the style-neutral pillar scores and the ESG score (Table 2).

Table 2: Significance and Explanatory Power of Traditional Style Factors and Style-Neutral Pillar Scores and the ESG Score in Both Europe and the United States

Traditional Style Factors	**EU**		**US**	
	Significance	**Explanatory Power**	**Significance**	**Explanatory Power**
Volatility	38.03%	0.82%	36.62%	0.53%
Growth	21.13%	0.30%	33.80%	0.39%
Value	39.44%	0.80%	46.48%	1.06%
Profit	21.13%	0.50%	26.76%	0.30%
Size	33.80%	0.74%	26.76%	0.45%
Style-Neutral ESG Factors	**Significance**	**Explanatory Power**	**Significance**	**Explanatory Power**
ESG	15.49%	0.32%	2.82%	0.08%
Environment	15.49%	0.25%	15.49%	0.21%
Social	8.45%	0.13%	12.68%	0.13%
Governance	29.58%	0.69%	21.13%	0.24%

Source: *Authors, 2019.*

Explanatory power and significance go hand in hand: Explanatory power measures the ability of the risk factor to explain the variance, whereas significance is a measure of how certainly the factor is truly explaining variance. As expected, both the significance and the explanatory power of traditional style factors are, on average, larger than those of style-neutral ESG factors. Nevertheless, in Europe, values of the Governance pillar rank just below the median values of traditional style factors, and both the ESG and the Environment sustainability factors have an explanatory power close to that of the Growth style factor. Conversely, in the United States, the relevance of sustainability data is weaker, but the explanatory power of the Environment and the Governance pillar scores is still larger than 0.20%. Note the top eight style-neutral key issues with the highest explanatory power (Table 3). In Europe, Labor Management has by far the largest explanatory power, whereas in the United States, Business Ethics & Fraud ranks the highest. Despite the heterogeneities between the European and the U.S. equity markets, the identified most-relevant key issues coincide. Differences are instead reflected in the ordering and magnitudes of explanatory power. Thanks to the granularity of these results, it is possible to identify the most-relevant key issues across each market and calibrate more informative E/S/G pillars or even the whole ESG score accordingly.

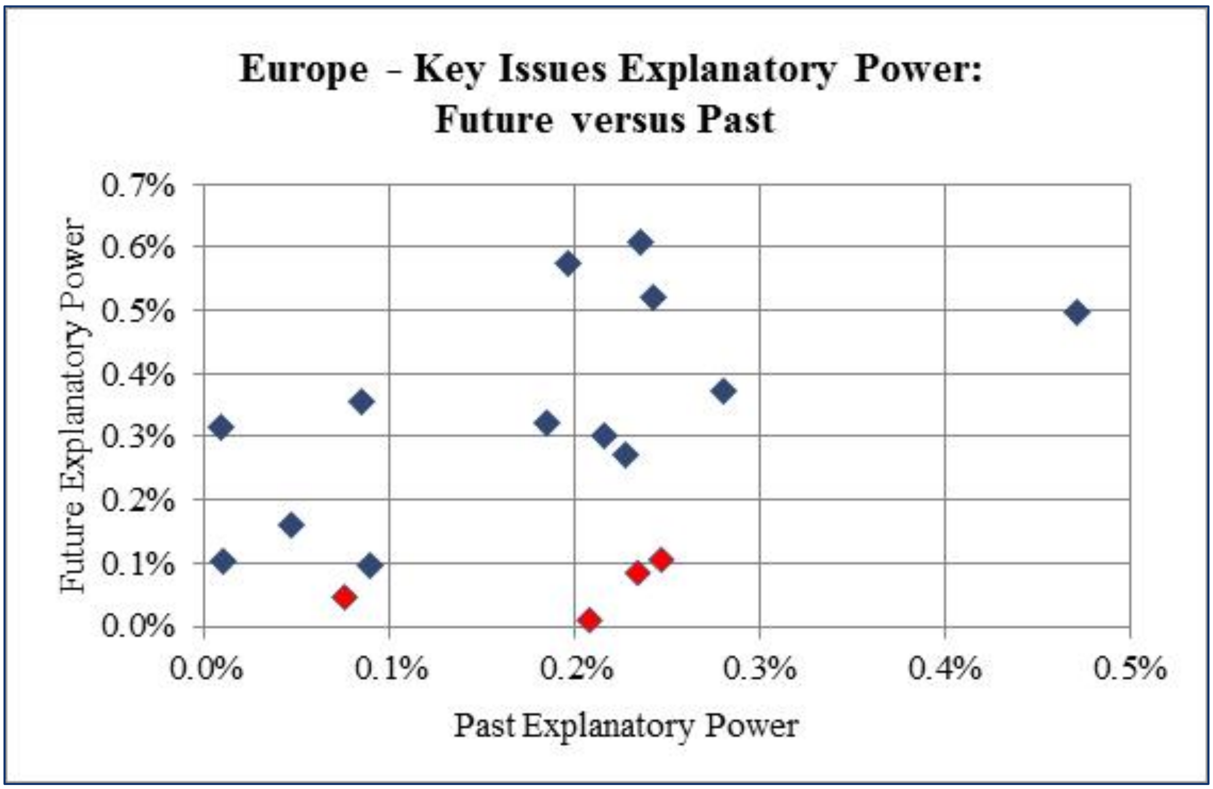
Table 3: Significance and Explanatory Power of the Strongest Style-Neutral Key Issue Factors in Both Europe and the United States

EU			US		
Style-Neutral Key Issue	**Explanatory Power**	**Significance**	**Style-Neutral Key Issue**	**Explanatory Power**	**Significance**
Labor Management	0.47%	29.58%	Business Ethics & Fraud	0.72%	39.44%
Business Ethics & Fraud	0.30%	16.90%	Anti-Competitive Practices	0.57%	43.48%
Toxic Emissions & Waste	0.29%	15.49%	Carbon Emissions	0.28%	19.72%
Corporate Governance	0.26%	16.90%	Water Stress	0.23%	21.13%
Health & Safety	0.23%	19.72%	Corporate Governance	0.20%	18.31%
Carbon Emissions	0.23%	12.68%	Labor Management	0.14%	9.86%
Anti-Competitive Practices	0.22%	15.49%	Toxic Emissions & Waste	0.13%	14.08%
Water Stress	0.21%	14.08%	Anti-Competitive Practices	0.10%	12.68%

Source: *Authors, 2019.*

The persistency of the explanatory power is investigated by comparing the adjusted R-squared computed on the factor model regression over the sample period from February 2013 to December 2017, denoted as "past," with the one over 2018, the last year of the sample period, denoted as "future." In Europe most of the time, the explanatory power is persistent over time (Figure 2; data points in blue); style-neutral key issues with high explanatory power in the past tend to rank higher later.

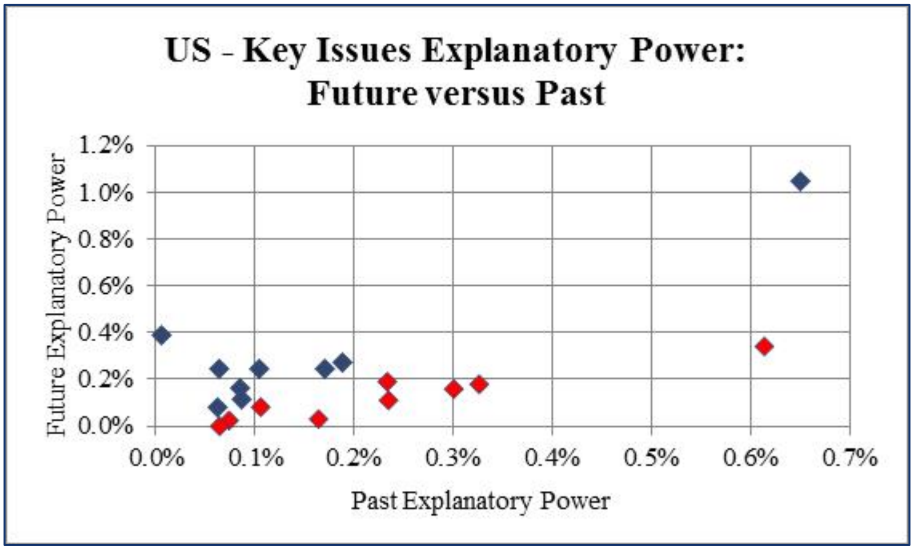
Figure 2: "Future" versus "Past" Explanatory Power of Style-Neutral Key Issues in Europe



Source: *Authors, 2019.*

The results for the U.S. equity market are the same (Figure 3). Differently from the European case, persistence in the explanatory power of key issues in the U.S. case is less strong, as almost half of the key issues showed no persistency over the two sub-samples considered (data points in red).

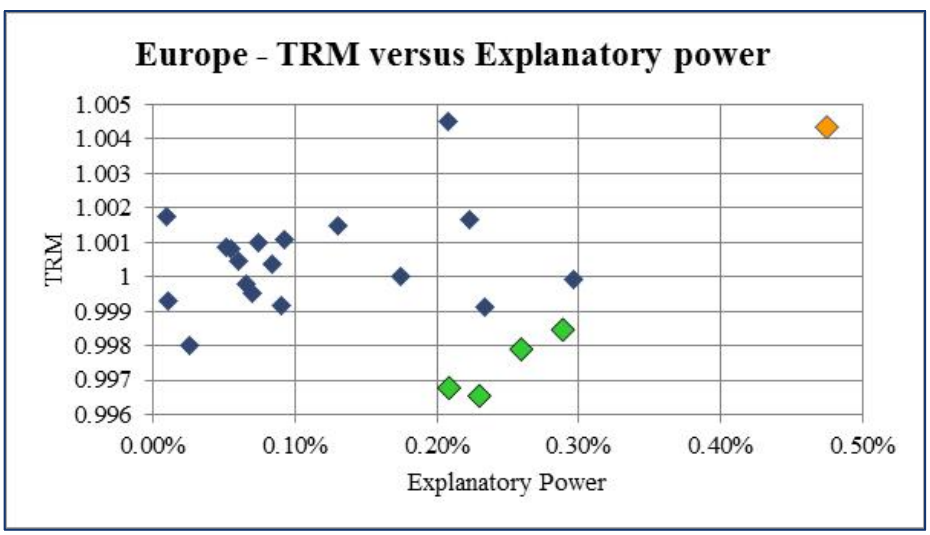
Figure 3: "Future" versus "Past" Explanatory Power of Style-Neutral Key Issues in the United States



Source: *Authors, 2019.*

For each relevant[3] key issue in the European market, its tail-risk mitigation ratio and its explanatory power are plotted (Figure 4). Labor management (data point in orange) has the strongest explanatory power, but it does not mitigate tail risk. In green are those key issues that have relatively strong explanatory power and also mitigate tail risk: in Europe, Corporate Governance, Business Ethics & Fraud, Water Stress, and Toxic Emissions & Waste.

Figure 4: Explanatory Power and Tail-Risk Mitigation of Key Issue Factors in Europe

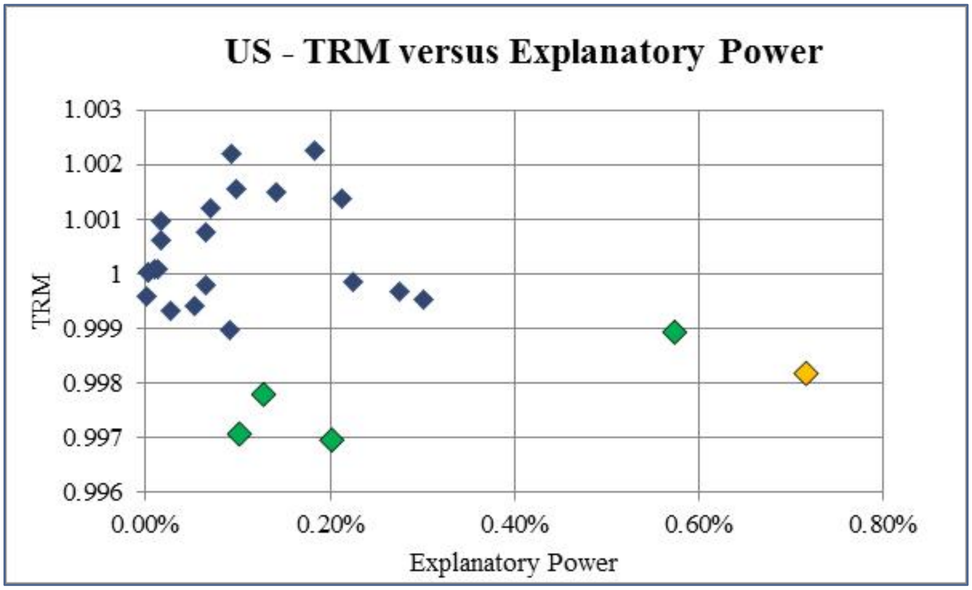


Source: *Authors, 2019*

[3] All those style-neutral key issues with strictly positive adjusted R-squared.

The results are the same for the U.S. equity market (Figure 5). In this case, the most-relevant key issue in terms of explanatory power, Business Ethics & Fraud (data point in orange), mitigates portfolio tail risk, too. As before, the most-relevant key issues in terms of explanatory power and TRM are highlighted in green, namely Anti-Competitive Practices, Corporate Governance, Toxic Emissions & Waste, and Health & Safety.

Figure 5: Explanatory Power and Tail-Risk Mitigation of Key Issue Factors in the United States



Source: *Authors, 2019.*

Conclusions

The analysis investigates the effects of sustainability-related information on portfolio tail risk. In the context of a fundamental factor model, we present a statistically based methodology to identify the most-relevant sustainability-related information driving equity returns. Breaking down the sustainability information to key issue granularity level, the analysis enriches the existing literature on socially responsible investing. Without relying on any subjective choice (other than the definition of the model structure), we detect relevant sustainability-related information based on a positive explanatory power resulting from factor univariate regression. Then, the tail-risk mitigation hypothesis is tested by comparing the expected shortfall before and after the application of a tilt toward informative sustainability-related data. Results show that a subset of ESG key issues and pillars shares similar characteristics in terms of explanatory power and significance to other risk factors well established in the literature. Among them, some actively contribute to portfolio tail-risk mitigation. The majority of the identified most-relevant key issues coincide across markets, even though their impact vary in magnitude from Europe to the

United States, thus highlighting the structural differences between these two markets. Results can be of interest to academics, practitioners, and investors. For academics, they shed light on the potential benefits of relevant ESG information on portfolio tail risk, and for practitioners and investors, they provide useful guidelines for achieving a better portfolio diversification while improving the portfolio's ESG characteristics.

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Figures

Tables

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Corporate Social Responsibility and Firm Outcomes: Some Intuition on Interpreting Statistical Models
A Comment on "ESG Risk Factors and Tail-Risk Mitigation"

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In recent years there has been a push from investors, activists and consumers to obtain more information on the sustainability practices of the companies in which they invest and from whom they purchase goods and services. As such, a number of ratings systems have been developed that attempt to quantify various aspects of a company's corporate social responsibility (CSR). A critical question for investors is whether they can use companies' CSR measures to predict firm performance and mitigate portfolio risk. Whether and how institutional investors should incorporate CSR metrics into their investment decisions remains an open question.

There are two differing views on the CSR–firm outcome relationship. First, classical models taught in economics suggest that firms will not voluntarily contribute to public goods or internalize any externalities they create. Under these models, CSR indicators such as voluntary pollution reductions, investing in community welfare, and increasing worker wages above market rates are all likely to come at the expense of a firm's profit. As such, firms partaking in these activities would be expected to have lower returns and make for a less attractive investment opportunity. Indeed, CSR activity could represent what economists call "agency problems," which occur when managers in the firm partake in CSR activity to curry favor for themselves in their local community rather than to increase the firm's profits (Tirole 2001). For example a bank may make large donations to a local charity because the CEO values the increased clout she will gain in the community. If this, rather than the Bank's profit, is the motivation for the giving, then higher CSR activity will be associated with lower company returns.

Alternatively, there are a variety of mechanisms through which CSR activity may increase profits and limit firms' exposure to risk (Edmans 2011; Servaes and Tamayo 2013). CSR may increase brand-value and appeal to consumers' preference for products and companies that do good for their communities (Kotchen 2006). Similarly, CSR measures may reflect firms' compliance with government environmental and safety regulations and minimize risk of large government fines such as those recently experienced by BP following the Gulf of Mexico oil spill and Volkswagen's emissions scandal. When there are government regulations such as a carbon tax, reductions in pollution can increase profits *and* lead to higher CSR scores.

Given the noisy signal that CSR activity provides for firm performance, how can institutional investors best make use of CSR measures when balancing portfolios? Research by Simon and Legnazzi provides a model to shed light on this question by taking 34 CSR measures from MSCI's Environmental, Social, and Governance Index and examining whether they are correlated with reductions in portfolio tail risk for U.S. and European companies from 2013 to 2018. Ideally, the measures they use could disentangle CSR activity that reflects agency problems with activity that reflects profit-maximizing behavior. Doing so is not easy, but increasingly disaggregated CSR measures allow for investors to choose CSR measures that they feel best predict firm performance. These factors may differ based on the country and industry of the firm. For example, it is not surprising that the CSR factors that predict better firm outcomes in Europe are not the same factors as those that predict firm outcomes in the United States. On average, European consumers are likely to have a greater preference for environmentally friendly companies, and the European regulatory system is more likely to punish firms that are not already engaging in CSR activities.

A few features of the model and data are particularly critical to understanding the results. First, the model is univariate, meaning that the results are largely correlational. This is useful to the extent that investors make decisions based solely on CSR factors. However, this is unlikely to be the case. Investors make decisions based on a variety of variables and CSR measures are likely to be highly correlated with, for example, the size, age, and market power of the firm. Portfolio allocations based on CSR will likely lead to selecting firms that are disproportionately old and large. This may bias investors away from younger firms who, ironically, are more likely to be developing environmentally friendly technologies. Models that predict firm outcomes should incorporate many features of a firm. Understanding how CSR predicts firm outcomes conditional on other firm characteristics would be of considerable use. More convincing models could also use causal inference techniques now common in economics and finance to identify the causal effect of higher CSR scores on firm outcomes.

A separate important feature of the model is that the CSR scores are normalized by industry. As such, when taking these results and using them to compare firms, the results are only applicable when comparing firms that are in the same industry. These results should not be used when investors decide their exposure to particular industries. Once investors have decided their desired industry allocation, these results can be used to compare firms within a chosen industry. Other caveats apply as well. The results are specific to the 2013–2018 time period for U.S. and European companies. Investors should always ask whether changing market and regulatory conditions might shift the CSR–firm outcome relationship in the future.

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