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The *Journal of Management for Global Sustainability* is a peer-reviewed scholarly journal devoted to the publication of original research in the field of management and global sustainability, with the latter defined as the broad set of interconnected issues that include, but are not limited to, the achievement of environmental preservation, social entrepreneurship, poverty eradication, social justice, desirable production and consumption patterns, species preservation, and spiritually rich lives at this time in our species' history on this planet. The journal publishes articles on how productive enterprises contribute toward realizing and achieving global sustainability so as to create socially just and spiritually-whole ways for all species to go on thriving indefinitely.

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OUR MOST IMPORTANT PROBLEM

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In 1986, widely honored scientist and intellectual innovator Richard Hamming gave a talk at the Bell Labs Morris Research and Engineering Center in Morristown, N.J. where he recalled a series of lunches at one of the labs. During those lunches he began asking, "'What are the important problems of your field?' And after a week or so, 'What important problems are you working on?' And after some more time (he) came in one day and said, 'If what you are doing is not important, and if you don't think it is going to lead to something important, why are you at Bell Labs working on it?'" (Hamming, 1986).

Hamming's questions need not be limited to scientists at one of the world's greatest research institutions of all time. "What is the most pressing problem facing us today? Are we working on it? If we are not working on it, why are we not doing so?"—these words might be appropriate for each of us in the short amount of time we are blessed with to be on this beautiful planet.

Given the history of the Jesuits and their tradition of "changing the world" through education inspired by repeated social innovations (Lowney, 2003), Jesuit universities and their business schools are especially called upon to explore such questions and to discover, in doing so, the most important problem facing us. Indeed, Pope Francis in *Laudato Si'* (Francis, 2015) seems to have little doubt about the most pressing challenge that we all, including our very species itself, face. He is asking us—in an encyclical that is unusual in its being addressed not just to Catholics or Christians but to everyone on this planet—to engage in dialogue about the already demonstrably harmful and potentially catastrophic economic, environmental, social, and cultural course we as a species are embarked upon. And to discover, from that dialogue, how we can make our own special contributions toward improving the trajectory of our current actions.

A year after *Laudato Si'* was published, Nobel laureate Paul Krugman also seemed to have little doubt about the most pressing problem we are facing, especially if we consider global policy issues to be indicators of important concerns for our species: "Last year was the hottest on record, by a wide margin, which should—but won't—put an end to climate deniers' claims that global warming has stopped. The truth is that climate change just keeps getting scarier; it is, by far, the most important policy issue facing America and the world" (Krugman, 2016).

A few months ago, Bill McKibben, one of our long term "canaries" in the "coal mine" of global unsustainability and author of many books including *The End of Nature* (1989) and *Eaarth: Making a Life on a Tough New Planet* (2010), asked the scary question "Has the human game begun to play itself out?" in the subtitle of his new book, *Falter* (2019). Jared Diamond, perhaps best known for his *Guns, Germs, and Steel: The Fates of Human Societies* (1999) and author of *Collapse: How Societies Choose to Fail or Succeed* (2005), provided a review of McKibben's book in an April 21, 2019 *New York Times Book Review* article. He observed that

> in the first half of the book, [McKibben] explains the present dangers to civilization, which include the risk of nuclear war and multiple hazards associated with climate change: increasing atmospheric carbon dioxide, threats to food production, rising sea levels, and ocean warming and acidification.

Diamond then notes that

> the middle part of the book discusses forces opposing solutions to the problems laid out in the first part—motivated variously by self-interest, grim realities, power, ideals and views about the proper role of government. These forces include Exxon, poverty, inequality, Ayn Rand, the Koch brothers, other very rich Americans, President Trump and Silicon Valley.…
>
> Finally, in the book's last section, McKibben offers his reasons for hope. Foremost among these are solar panels, which are making cheap renewable energy available around the world, and nonviolent movements, whose successful practitioners against entrenched, well-armed oppositions have included Gandhi, Martin Luther King Jr., Earth Day demonstrators and McKibben's own group, 350.org.

Diamond concludes his rich and valuable review with the following paragraph:

> It will take many different voices to persuade the world's diverse citizens and corporations to collaborate on solving the world's biggest problems.

> McKibben's voice has been an influential one. My hope is that his new book will strengthen the motivation of those already sympathetic to his views. My fear is that it won't convince many who remain hostile to them. I hope that my first prediction proves right, and that my second proves wrong. (Diamond, 2019)

The following week, John Lanchester (2019) wrote that climate change "is the greatest challenge humanity has collectively faced" in the first sentence of his *Times* review of two other new books (Wallace-Wells, 2019; Rich, 2019).

SO WHAT?

In addressing the realities of our recent, current, and likely future situations, the editorials and articles of the *Journal of Management for Global Sustainability* have frequently called for us, in the words of Jim Collins, "to confront the brutal facts, yet never lose faith" (Collins, 2001) and will continue to do so, and perhaps even more strongly and stridently in the future.

The scary thing about perspectives that suggest that climate change and global unsustainability are "existential threats" is that we are not talking about the writings of authors such as Camus, Kierkegaard, and Sartre; we are talking about threats to the very existence of our species as a species. One of the major contributions of *Laudato Si'* is how Pope Francis states, both forthrightly and directly, that global unsustainability is a moral issue and that the damages we are doing today to the most vulnerable and to future generations across time are moral failings of the greatest magnitude. The ways that we have chosen for producing and consuming the necessities and luxuries of our lives and how we distribute the benefits and costs of those production-consumption-distribution processes all contribute to the unsustainable nature of our current situation. We are all part of the problem of global unsustainability, and business schools are no exception—they, too, are part of the problem.

The clear emphasis of *Laudato Si'* on the immorality of our contributions toward creating an unsustainable present for many and an unlivable future for all is pertinent to the current state of teaching, research, and conceptualization of members of Jesuit business schools in particular. Indeed, even if Jesuit business education may be slightly better than average when it comes to addressing

questions of global unsustainability, it would be difficult to defend the assertion that the dominant teaching in marketing, finance, and accounting in Jesuit business institutions is very different from that found in other schools. The occasional course in green marketing or marketing to the "bottom of the pyramid" aside, it would be very hard to claim that courses in finance, marketing, accounting, economics, management, operations, communications, negotiation, law, and perhaps even ethics in all business schools, including Jesuit ones, are not devoted primarily to giving our students the skills and attitudes to "take-make-waste-faster-and-faster-for-the-richer-and-richer"—and to feel very good about themselves as they do so.

In recognizing that global unsustainability is, at its very core, a moral problem of the greatest magnitude and not just a business concern, all universities and their business schools have the obligation and opportunity to conduct themselves in ways that will make them stop adding to the problem and start becoming vehicles for solutions. The worldwide network of Jesuit business schools, in particular, is especially called upon to explore the realities of our current situation, reflect upon those realities and our resources for making positive contributions, and take actions that might impact not only educational institutions but also the world.

Arthur Taylor, when he was dean of Fordham University's Graduate Business School from the late 1980s to early 1990s, once invited Roland Christensen, the master of case teaching at the Harvard Business School, to join a faculty retreat and lead a session on case teaching. Frank Werner, who had been one of Christensen's students at HBS, was asked to host Christensen during the visit.

At the end of the trip, Frank observed to Roland, as he was driving the latter back to the airport for his return flight, that he must receive many such invitations, and asked why he accepted this one. Christensen replied that Frank was correct about the invitations and that he had asked his dean if he should accept this one when it came in. His dean said yes, that it would be good to accept because one area in which HBS might be competitively vulnerable was that which was somehow related to the deepest purpose and meaning of business organizations and education—an area to which spirituality and religion might have special access. He was curious, therefore, what Fordham might be doing as a faith-based business school in an area where HBS might be vulnerable.

When Frank asked Roland what he had learned during his visit about what Fordham was doing in such a domain, Christensen replied, "Not much."

Fordham, unfortunately, was not leveraging its core Jesuit values and heritage to pioneer the transformation of business education and research. Indeed, in terms of innovation for the transformation of business education, Christensen's reply was probably true for essentially all business schools—faith-based and otherwise. And it probably is still true today, when the need for business education transformation is even greater in our much more serious situation.

Three decades after that Christensen-Werner conversation, the need for deep transformations, driven by global unsustainability, in what and how we produce, distribute, and consume as suggested in *Laudato Si'* offers many opportunities for Jesuit business schools to provide dramatically different answers to the question that Roland Christensen was exploring. Answers that just might light the fire that transforms business education around the world.

NOW WHAT? A SECOND CHANCE FOR JESUIT BUSINESS SCHOOLS

Jesuit business schools have, in a number of very significant ways, pioneered approaches and actions that have actively contributed and continue to contribute toward a more just and sustainable world. Commitments to social justice and the alleviation of poverty, for instance, have long been major foci across virtually all of Jesuit business education. Centers and programs for global sustainability are located on a number of campuses, and the schools have been outstanding leaders in the domains of social innovation and social entrepreneurship. The International Association of Jesuit Business Schools (IAJBS) made a deep commitment to global sustainability in 2009. Although the many other such activities are too numerous to list here and should not be minimized or overlooked, other exciting opportunities still lie ahead and are yet to be seized; three of these are discussed next. While they are attractive for the member schools and faculty of the IAJBS and CJBE (Colleagues in Jesuit Business Education) in particular, they nevertheless present exciting opportunities for all business schools. After discussing these three areas of opportunity, we will provide a short introduction to the articles in this issue of the Journal.

THE IAJBS WORLD FORUM

The IAJBS recognized this existential threat ten years ago when its 15th World Forum met at the Xavier Labour Relations Institute (XLRI) in Jamshedpur, Jharkhand, India. That World Forum, the theme of which was leadership for sustainability, was different in one major and perhaps almost unique aspect—a resolution submitted, passed unanimously, and ratified the next day by the Executive Board of the IAJBS. The resolution called for the World Forum to devote itself for the next ten years to the broad theme of contributing toward a more sustainable world. Then, at the World Forum at Ateneo de Manila University in Manila the following year, Rudy Ang and his IAJBS colleagues suggested that the organization might create a journal on sustainability. The first issue of that journal, the *Journal of Management for Global Sustainability*, appeared in 2013.

Over the past decade since 2009, the words used to describe the goal of achieving a sustainable world have evolved roughly along the lines of sustainability, sustainable development, global sustainability, and flourishing. Now, perhaps, we may add "regeneration," which refers not just to doing less harm or no harm at all but actually to restoring our broken world—"healing our common home," as Pope Francis might say. The definition of sustainability offered in the first issue of this journal, interestingly enough, explicitly addressed the need for "healing our broken world" by substituting the words "without compromising" as found in the popular Brundtland Commission definition of sustainable development with "while enhancing."

> *We define global sustainability as … a process that meets the needs of the present generation while enhancing the ability of future generations to meet their own needs. Global sustainability envisions a world that works for everyone with no one left out.* (Stoner, 2013: 2)

The 25th World Forum will meet in July 2019, this time at the Xavier Institute of Management (XIMB) in Bhubaneswar, India. It will also serve as the inaugural South Asia Regional Chapter Meeting of the Colleagues in Jesuit Business Education. The theme of this Forum, "Innovate and Flourish," honors John Ehrenfeld's early definition of sustainability as "the possibility that human and other life will flourish on the planet forever" (Ehrenfeld, 2009).

Given that the 2019 meeting falls on the tenth anniversary of the commitment made at the XLRI conference in 2009, it is very likely that a new resolution inviting the World Forum to recommit itself to another ten years of leadership for a sustainable world—or perhaps to commit to a regenerative one—will be offered.

The IAJBS World Forum is, of course, not the only annual conference that had historically chosen a new and different theme each year. Almost all conferences, in fact, do exactly that. However, just as the World Forum "put a stake in the ground" by committing itself for ten years to the theme of leadership for sustainability, other professional organizations or even major foundations can make similar commitments to focus both their and our energies on "humanity's greatest challenge." In the domain of professional organizations for management academics alone, for example, the Academy of Management, Eastern and other regional Academies of Management, Management and Organizational Behavior Teaching Conference, and others could send the signal to the world that the issues of climate change and global unsustainability must no longer be ignored and that their members are going to give these the attention they have long deserved but not received. And perhaps major foundations, too, like the Bill & Melinda Gates Foundation, MacArthur Foundation, Ford Foundation, Susan Thompson Buffett Foundation, and others will make similar deep and longer-term commitments to marshal the resources we need to inspire, fund, and honor those who are willing and eager to do what must be done if we and our children are to have a future worth having.

TRANSFORMING OURSELVES AND BUSINESS EDUCATION

If we look for two major transformations that our species might need for dealing with our current situation of global unsustainability, for moving toward a flourishing and regenerative future, one of those might be at the individual and the other at the systems level. As individuals, we may need to undertake the "ecological conversion" that Pope Francis calls for in *Laudato Si'*. We may need to become different people as producers, consumers, and citizens. At the systems level, we may need to transform the broken producing-distributing-consuming system that serves so much of the world so poorly even as it is destroying the capacity of the planet to support our own and other species.

How are we to bring about these transformations? The network of Jesuit business schools could provide valuable contributions to the world in both of these domains.

EXPLORING TECHNOLOGIES FOR ECOLOGICAL CONVERSION

There may be some irony in the fact that we are investing billions and billions of dollars to investigate a variety of technologies for addressing the problems of our producing-distributing-consuming system but almost nothing to explore how we can become the kinds of people who will use those technologies to create a sustainable/flourishing/regenerative world. We are simply not making large-scale investments to discover how we can transform ourselves; in fact, we are making hard technology investments at the systems level at a time when many observers believe we already have all the technology we need to create a sustainable world (e.g., the 100 projects described in Paul Hawken's *Drawdown: The Most Comprehensive Plan Ever Proposed to Reverse Global Warming* [2018] and the integrated approach to transforming the global economy using existing technologies as described in *A Finer Future: Creating an Economy in Service to Life* by Lovins, Wallis, Wijkman, & Fullerton [2018]). The problem is that we are simply not using the technologies we already have.

If we free ourselves from automatically thinking of technology as something mechanical, often embodied in machinery, and directed toward producing physical products and instead remember that we can define it simply as "a process for getting something done" or as "a system by which a society provides its members with those things needed or desired" (Your dictionary, n.d.), we may find ourselves called to accept the invitation to invest substantively in figuring out how to use our existing centuries- and millennial-old technologies of personal transformation more effectively as well as discover new ones.

We can look for ways in which we can make those technologies of transformation more effective, rapid, and joyful for those sharing, acquiring, and using them. And we can look for ways to invent brand-new ones. We might note, for instance, that the spiritual exercises of St. Ignatius, something close to home for Jesuit institutions, can be looked at as a five-century-old technology of personal and spiritual transformation, one that has proven itself over and over again. The temptation to explore very promising technologies of personal transformation can

therefore be quite appealing given so many billions already being invested in the search for systems level technologies aimed at changing our ways of producing, distributing, and consuming.

When we focus on ourselves and our ways of being in the world, it is also tempting to think of investing appreciable monies in the creation of a series of innovative research centers that would look into technologies of personal transformation. CARTT (Centers for Action and Research into Transformational Technologies) is almost certainly a label that can be greatly improved; nevertheless, whatever we choose to call the endeavor, it might be valuable to look, through the lens of technology, at well-established and powerful transformational experiences such as the Spiritual Exercises of St. Ignatius, yoga, meditation, mindfulness practices, appreciative inquiry, the Ashoka U set of campus programs and initiatives, Landmark Education's set of programs, and many, many others that provide profound and lasting positive change in people's lives and ways of being in the world. And then there are emerging approaches that may also be worthy of serious exploration, such as Theory U (e.g., Scharmer, 2016), Humanistic Management (e.g., Pirson, 2017), and Quantum Leadership (Tsao & Laszlo, 2019).

There is a nascent possibility that one or more such centers might get started soon. Indeed, it might be particularly appealing to explore technologies of personal transformation at faith-based universities, both Jesuit and otherwise, given that so many of these centuries-old technologies for transforming ourselves as human beings arise from and/or are grounded in spiritual ways of being in the world. Faith-based universities might be particularly at home providing leadership in discovering what makes these technologies have the impact they have, how we can make them available to more and more of the world's peoples—how we can make them cheaper, faster, better—and, very importantly, how we can protect ourselves from and prevent their misuse.

BUSINESS SCHOOL LEADERSHIP

In "Torn Between Two Paradigms: A Struggle for the Soul of Business Schools," Chris Laszlo, Robert Sroufe, and Sandra Waddock (2017) call for taking action in transforming the neoliberal narrative that dominates, to a very large extent, the teaching of business around the world. As has been noted in this

journal and elsewhere, the all-pervasive, self-reinforcing, internally-consistent, and environmentally-destructive global system of producing, distributing, and consuming is so well entrenched and so fully integrated within itself that it seems impervious to any efforts at changing it. However, since it is also so complex and interconnected, there are a seemingly endless number of places where the system can be entered into and hopefully disrupted for positive ends.

With the objective of turning business education into a vehicle for transforming our whole global producing-distributing-consuming system, the IAJBS/CJBE application to the 2016 MacArthur Foundation 100&change competition was just one of many possibilities. On June 2, 2016, the MacArthur Foundation announced a $100 million competition to solve a major societal problem. The possibility of the Jesuit business schools joining the competition was discussed briefly during the July 10 business meeting of the CJBE at Le Moyne College in Syracuse, New York. A week later, at the 23rd IAJBS World Forum in Nairobi, Kenya, the following resolution was passed unanimously and approved the next day by the Executive Board of the IAJBS:

> The annual meeting of the IAJBS requests the IAJBS leadership, CJBE leadership, and the rest of the network of Jesuit business schools to work together to apply for the MacArthur Foundation 100 million dollar 100&change competition with a project to transform Jesuit business education to be fully aligned with the wisdom in *Laudato Si'*, with our universally-valid Jesuit educational tenets, and with the need for global sustainability, social justice, and poverty alleviation. (July 18, 2016)

On October 2, 2016, a proposal to use the transformation of Jesuit and all business education as a vehicle for transforming our global producing-distributing-consuming system was submitted to the MacArthur Foundation. There is a bit of ambiguity concerning how the various applications are counted, but by one count the number is 1,407. On this count, the IAJBS/CJBE application was one of the 1,406 applications that did not win the $100 million prize.

The submission deadline for entries to the 2019 100&change competition is in August 2019. Efforts are currently being made to put together a new application that is very similar to the original 2016 one. This new application will continue to invite Jesuit and other business schools to transform their curricula and much of their research by aligning them with the realities of the 21st century and the need

for a regenerative world. Indeed, the possibility of such an application has already been described in this journal (Stoner, 2018).

It would not be necessary for a faculty member to be in a university that wins the MacArthur Foundation prize—a highly unlikely event—to make a contribution toward transforming business education and our global producing-distributing-consuming system. Any teacher in any of the business school disciplines can look at her or his syllabus with a view toward deciding what is appropriate for the realities of the 20th century versus what is appropriate for those of the 21st, and then start making the kinds of teaching and research adjustments that the realities of the 21st century call for. Faculty members at Regis University's Anderson College of Business and at Fordham's Gabelli School of Business are, in fact, either starting or have long been engaged in exactly this type of inquiry. Given that it is difficult to defend teaching from a syllabus that is appropriate for the 20th century and not the 21st, it is highly likely that many others will follow suit by exploring on their own and sharing what they are doing and learning with others.

HOW TO MAKE A DIFFERENCE? ALMOST TOO MANY OPPORTUNITIES TO CHOOSE FROM

As this editorial was being written, the Anderson College of Business announced a new track in its Masters of Science in Finance and Economics program in collaboration with the Capital Institute and other partners committed to exploring and creating approaches to regenerative finance on a local and a global level. The program will address exactly those problems in the global financial system that are such a barrier to creating a sustainable/flourishing/regenerative world.

There are many opportunities for each of us in what we teach, what we research, how we define service, what we choose to purchase—or rent—and consume, what we invest in, and how we vote. The hard questions are not about finding opportunities and challenges but in choosing from among many attractive alternatives. And about how much of our time, energy, and other resources we will devote to the selections we make.

We know what the problem is. The question is what each of us will do about it.

AND NOW TO THE ARTICLES IN THIS ISSUE OF THE JOURNAL

Each of the five articles in this issue provides ways by which change and transformation on the personal and/or systems levels can contribute to a more sustainable world.

Bernard Arogyaswamy argues that while innovation often creates competitive advantage and economic growth, it can also have negative impacts, e.g., placing burdens on already limited resources, environmental damage, social inequalities, and even diminished social mobility. In describing how innovation strategies can be designed and chosen for contributing more effectively to the creation of a sustainable world and how sustainability-focused actions can actually be a source of innovation, he develops a three by four matrix that offers a framework for creating and analyzing sustainability-focused initiatives and ideas. He places product, process, and managerial innovation on one axis and four sustainability approaches (cost reduction and differentiation-focused actions for environmental sustainability; employee and community-directed actions for social sustainability) on the other. The result is an array of 12 sustainability strategies that corporations can use as guides for achieving goals like lowered emissions, less material wastage, and greater employee wellbeing and community welfare, among others.

To help in the shift toward renewable energy, Claire Siegrist and Evangelos Katsamakas present the results of a business education research project that looked into the question of electricity generation using a distributed system based on renewable energy vis-à-vis a centralized one based on fossil fuels. They describe a decision support system that can help policymakers and stakeholders assess the feasibility of solar energy systems for rooftops. The system uses metrics based on existing regional assessment models and which include information on variables such as costs to consumers, regional demand, and government support. The paper thus shows how to estimate costs and amounts of electricity generated to see how a renewable energy system might perform against traditional fossil fuels and how it might reduce overall emissions. Use of the support system can therefore lead to actions that will help reduce costs and emissions even if distributed generation may not entirely replace centralized systems as of yet.

Another tool that is the result of a business education project comes from the work of Karyl Leggio and Col. Reid Nichols. Students used Monte Carlo simulation

(a technique that is often used to understand risk) as a financial modeling device for supporting decisions on how to allocate resources and justify costs related to the Chesapeake Bay Interpretive Buoy System, a network of buoys that provides users with the technical and scientific information needed to "improve marine forecasts" and "monitor the health of the [Chesapeake] Bay." The resulting tool handled enough complexity and had sufficient substance that it was used by the National Oceanic and Atmospheric Administration (NOAA) in its budget request to Congress. It was seen as particularly useful for assisting NOAA in its task of protecting and preserving Chesapeake Bay, an important source of seafood and the home of a major port on the east coast of the United States.

The work of Quan Le and Grace Jovanovic emphasizes the importance of partnerships in transforming individual lives and moving trading systems toward the creation of more sustainable outcomes. Using a trade model in which coffee is bought directly from Nicaraguan farmers at fair prices that respect previously established price floors, the student-founded *Café Ambiental* provides its coffee producers with economic stability and encouragement. This in turn allows the farmers to transition to organic farming while improving the health, education, and economic well-being of their families. The students and faculty working in this partnership with the farmers, on the other hand, experience aspects of personal transformation through business and life lessons that are consistent with the goal of solidarity with the marginalized.

Acknowledging the many ways by which progress in the sharing economy can contribute to a more sustainable world, Alain Decrop and Antje Graul tackle the challenge of improving the participation of providers in said economy through collaborative consumption schemes which can lead to less waste, reduction of new purchases, and enhanced recirculation of products. Their study presents evidence that both reduced perception of risk and enhanced system trust can improve the likelihood of participation in a sharing platform. Consumers are more willing to share their assets as providers in what the authors call a "reciprocal (monetary) compensation" arrangement rather than in a "generalized reciprocity" setup because they perceive a higher degree of risk with the latter—they have no guarantee of "what they are getting in return" in the generalized reciprocity situation. The authors also show that these collaborative consumption schemes are more attractive when a not-for-profit market intermediary facilitates the sharing process. It is

therefore important to understand these aspects of the sharing economy as such and to take action on them if the supply of shared assets is to grow, meet the increasing demand for sharing resources, and achieve the advantages of doing so.

Indeed, as these projects inspired by business education suggest, there are likely to be many other examples in our business schools that can nudge us into action toward creating a more sustainable, flourishing, and regenerative world, whether they help us make decisions on an organizational and systems level or inspire us on a personal one.

POST SCRIPT

For those of us, by the way, who are tempted to ask the kinds of questions that Hamming did, he concluded his description of those Bell Labs lunches with the following punchline:

> "*I wasn't welcomed after that; I had to find somebody else to eat with!*"

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BUSINESS STRATEGIES FOR SUSTAINABILITY-MOTIVATED INNOVATION
A Conceptual Framework

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ABSTRACT

Innovation has been and continues to be a key factor in the competitive advantage of business firms and economic growth of nations. However, while the creation of new offerings that are appealing to customers is central to corporate success, substantial negative outcomes may accompany or follow the unbridled pursuit of innovation. This paper investigates, among others, environmental damage and the diminution of social and political stability as problems arising from innovation and introduces a framework that may be used to enhance environmental and social sustainability through innovation. For the purposes of this study, innovation is viewed according to three types: product, process, and managerial. We also collapsed numerous sustainability strategies that have been identified in the literature into four categories: cost- and differentiation-based (environmental) and employee- versus community-oriented (social). The three innovation types are arrayed against the four sustainability strategies thereby yielding twelve approaches to innovating with sustainability in mind. Numerous examples are provided to illustrate how the framework is being or may be used. Such sustainability criteria can also serve vice-versa as drivers of organizational innovation.

KEYWORDS

corporate innovation; innovation types; environmental strategies; social sustainability; CSR strategies; sustainable innovation

INNOVATION AND ITS DISCONTENTS

Defined as the creation of a new offering which has market appeal and results in the creation of wealth (OECD, 1997; Keeley, Pikkel, Quinn, & Walters, 2013), innovation has been the basis for the economic success of numerous individuals and organizations as well as instrumental in the rise and prosperity of countries such as the United States (Tohidi & Jabbari, 2012; Young, 2006). In this context, wealth includes financial profit as well as improved customer experience and additions to the store of knowledge (O'Sullivan & Dooley, 2009; Thompson & MacMillan, 2010).

In seeking new opportunities and driven by a passion to satisfy unfulfilled, emerging, or latent customer needs, the individual entrepreneur has often served as the seed from which large corporations have sprung (Ries, 2011; Meyer & Crane, 2014). Firms such as Caterpillar, Thyssen, Honda, Hewlett Packard, Microsoft, Wedgwood, and Facebook started small, positioning themselves first on a slice of the product-market-technology nexus and gradually expanding along one or more of those dimensions. Some compete by developing new products or applications (e.g., 3M, Sony, Apple) while others such as Unilever, Avon, and Harley-Davidson excel at building and retaining a core customer base as they adjust to the changing needs of the market (Hughes, 1986; Gordon, 2016). Nucor Steel achieved competitive advantage by making the manufacturing process and service more efficient (The Economist, 2001). Southwest Airlines and e-Bay developed a business model that offered a new value proposition to a specific market segment (Brelis, 2000; Osterwalder & Pigneur, 2010).

Many of these storied corporations have demonstrated the ability to transition from being niche players to achieving dominance in an ecosystem. The key to their continued success, however, has almost always been their ability to innovate by increments and/or through industry-disruptive activities (Tushman & O'Reilly, 1997; Christensen, 1997). Even once-dominant firms have made innovation of various types the centerpiece of their resurgence—General Motors had to react to new entrants with better products and lower prices in the 1980s (GM, 2014); Microsoft had to innovate when it was clear that near complete reliance on Windows and Office would lead to stasis or decline (The Economist, 2017).

The race to innovate, though, has a darker side despite its numerous benefits (e.g., increased longevity, speedier transportation, instant communications, and "on the go" entertainment). Looming resource constraints, spiking carbon emissions, widening inequalities, and declining social mobility have combined to threaten

ecological and social sustainability and, as recent in-depth studies have astutely observed (Brill, 2018: 34–39; Stewart, 2018; Levitsky & Ziblatt, 2018; Applebaum, 2018), are shaking even the very foundations of democracy and free market capitalism. We explore in this article some of the "negative spillovers" of innovation, particularly with regard to its impacts on environmental and social sustainability. However, we also cross-classify different types of innovation against various aspects of environmental and social sustainability to enable the development of strategies for "innovating with sustainability." One of the purposes underlying the proposed framework, therefore, is the amelioration or even avoidance of some of the problems arising from the race to innovate. Such a framework can serve as a guide for companies (and responsible executives) in developing fresh perspectives on enhancing sustainability. Researchers, on the other hand, can focus on the degree to which firms achieve sustainability through innovation and measure the effectiveness of such efforts. Comparative studies of corporate sustainability within and across industries can also prove to be particularly instructive. Finally, the interactive relationship between innovation and sustainability can also serve as a lens for analyzing cases particularly in business schools that place an emphasis on issues of social and environmental justice.

SUSTAINABILITY OF THE INNOVATION-CONSUMPTION-GROWTH CYCLE

The cycle created by the rising expectations of consumers, corporate and other societal innovation, and national economic expansion can be extremely beneficial but may also have damaging outcomes as mentioned earlier. Yet positive feedback (Arthur, 1996) between innovation and consumption seems to have become a part of people's mindsets in much of the modern world.

Customer pull and technology push mutually reinforce each other in driving corporate decisions toward producing goods and services (Schilling, 2017). The consumption-innovation cycle, without a doubt, has contributed to the economic growth of nations and the financial success of enterprises, yet it has also accelerated the rate of resource depletion, material wastage, and carbon emissions as well as incidences of income inequality and other factors that erode environmental and social sustainability. Consumption, sometimes verging on consumerism, also tends to reinforce values such as individualism, short-term thinking, and emphasis

on local priorities, thereby weakening empathy, future orientation, and a global perspective, just as Pope Francis notes in *Laudato Si'* (2015). He is concerned that consumerism, which has contributed to rising levels of waste, carbon emissions, and resource depletion, has ravaged the planet, our common home. He appeals directly to consumers to moderate their needs, make do with less, and attach more importance to community, sharing, and reflection than to ownership and self-orientation. Indeed, to shift our focus away from the "technocratic paradigm," Walker (2013) goes so far as to argue that spirituality should be the fourth dimension of sustainability in addition to economic, environmental, and ecological considerations, enabling us to design systems rather than products and thereby making us more reflective and less materialistic.

Pursuing economic growth based on the engine of innovation alone, therefore, has flaws and perils, some of which have been noted earlier. First, the rate of innovation has to accelerate in order for growth to continue. This, as one author puts it, may require developments as groundbreaking as the internet every decade or so on average (West, 2017). Second, numerous scholars have pointed out that output (GDP) and its growth as measures of economic wellbeing are flawed—not only does a measure like GDP include elements such as expenditures on crime, health care, remediation of environmental damage, etc., it also omits items such as work performed at home. Inequalities and social challenges posed by the pursuit of growth at all costs can thus obscure both limits to and drawbacks of growth (Phillips, 2006; Pissourios, 2013; Thiry, 2015). Indeed, alternative measures such as the Genuine Savings Index, the Sustainable Society Index, and the Human Development Indicator (Strezov, Evans, & Evans, 2017) have been proposed yet a single dimension measure such as GDP remains most widely used due mainly to its simplicity and narrow focus on economic growth. In other words, innovation can both lead to the growth of firms and nations and be an indirect yet significant factor underlying rising disparities and the growing discontentment among large swathes of the population especially in the developed world (Rotman, 2014).

A third disadvantage to glorifying growth above all else is innovation that results in the replacement of millions of phones, TVs, cars, and appliances every year as this can cause a crisis in the disposal of used devices as well as shortages of, and cost increases in, the raw materials used (Ahmed, 2016). The danger posed by a continued rise in the use of fossil fuels and their resulting carbon emissions, coupled with the limited availability of water in many parts of the industrializing world,

makes for a situation where continued growth into the foreseeable future appears to be unrealistic (Brown et al., 2011; West, 2017). Innovating in ways that address the harmful environmental and social effects of our current paradigm through designs that improve environmental and social sustainability is an effective means, therefore, by which to address the problems created by the market-technology-growth cycle. We now explore some ways in which this can be done, starting with a review of some of the different types of innovation pursued by corporations.

TYPES OF INNOVATION

Innovation covers new products, processes, and management techniques and helps increase the availability, affordability, and variety of goods and services, thereby enabling firms to achieve a competitive advantage. There are many types of innovation, the best known being the development of radically new or incrementally different products and/or services (Schilling, 2017; Rothaermel, 2015). Once new offerings pique the interest of innovative consumers and succeed in attracting early adopters, process innovation is often called for to increase efficiencies, particularly if competition becomes more intense. Improving quality, lowering the cost of operations, raising throughput rates, and other such actions contribute to these efficiencies (Ettlie & Reza, 1992; O'Sullivan & Dooley, 2009). Other types of innovation acquire more competitive importance later on in the life cycle, including application-based innovation (finding new uses for existing products, e.g., doubling up mobile phones as cameras and navigation devices and extending the use of thin films from tapes to screen protectors, highway reflectors, and solar panels), marketing innovation (which includes finding new approaches to product delivery, e.g., Dell's direct-to-consumer strategy and Zara's decision to understock garments to create pent-up demand), and business model innovation (e.g., leasing in addition to sales, providing a free and a premium service, and using internet platforms to offer customized, low priced services) (Schilling, 2017; Moore, 2004; Keeley et al., 2013).

Creating an organizational climate in which new ideas are nurtured, shared, tested, and brought to market is often critical for maintaining an edge in innovation, especially in industries where user feedback is central to success. Termed managerial innovation, this capability, for instance, includes establishing suitable structures and processes by implementing decentralized, autonomous teams for new product development, fostering "hot spots" for informal interactions, and offering rewards

for ideas that lead to successful new products. Creating a culture that tolerates dissent and encourages learning, the sharing of ideas, and the formation of social capital, among others (Gratton, 2007; Büschgens, Bausch, & Balkin, 2013; Keeley et al., 2013), is also integral to managerial innovation. For the purposes of this paper, we shall organize innovation into three categories that encapsulate the entire gamut of innovation types: product, process, and managerial.

SUSTAINABILITY STRATEGIES: ENVIRONMENTAL AND SOCIAL

Epstein (2008), Blowfield and Murray (2014), and Bonini and Bové (2014), among others, note that numerous firms are beginning to view sustainability as being essential to future success. Laszlo and Zhexembayeva (2011) identify seven approaches for integrating environmental sustainability which range from compliance and lowering of costs to differentiation and raising of industry standards. Companies that are interested in pursuing more environmentally sustainable strategies typically progress along the "ladder of sustainability," beginning with a minimalist position of compliance or cost reduction before moving on to more ambitious efforts such as appealing to new markets (millennials, for example, who may be more concerned about environmental issues) or distinguishing themselves from their competition by offering refurbished, reusable, or remanufactured products, among others. For convenience, we categorize all environmental sustainability strategies as being either cost reduction- or differentiation-focused approaches.

With regard to social sustainability, we draw on the corporate social responsibility (CSR) literature. Most scholars and executives have come to accept, by and large, that while firms must be profitable to continue existing, they need to balance the search for ever-increasing returns with the continued wellbeing of both their stakeholders and the societies in which they operate (Moon, Crane, & Matten, 2005; Swanson, 2008). There are a variety of frameworks for conceptualizing, and developing actionable ideas for, the social responsibility of companies. Among these models are Carroll's (1979) CSR pyramid, which consists of economic, legal, ethical, and discretionary purposes that are arranged hierarchically and with the top of the pyramid being where the firm decides how it can best add value to society; the stakeholder perspective, in which a corporation identifies ways it can optimize the satisfaction of all its main constituencies, recognizing that none of them may have all their expectations of the firm realized (Freeman, 2010); the triple bottom line, which, again, is a guide for

achieving balance among economic, social, and environmental criteria (note that the latter is not explicitly included in the CSR pyramid and stakeholder perspectives) (Elkington, 1997); and Porter and Kramer's (2011) shared value approach, in which benefits to society are aligned with and arise from the firm's core competency, technology, or purpose, thereby contributing to the welfare of both the firm and society. It is worth mentioning that the shared value approach, though criticized at times for being self-serving with only incidental social benefits, can serve as a practical first step toward achieving a CSR commitment.

The arenas in which CSR efforts are deployed the most are the community, market, and employees. Community CSR includes support extended to causes in health, education, human rights, etc. Market CSR is directed toward reinforcing the firm's success by offering community support. Employee CSR focuses on improving working conditions (e.g., safety, child care, work-life balance), ensuring workers' rights (e.g., gender rights, freedom from discrimination), treating employees with respect, retraining them, and so on (Hess, Rogovsky, & Dunfee, 2002; Caruana & Crane, 2008; Moon, 2014). For this paper, we categorize social sustainability strategies as being either community- or employee-directed, with the market dimension folded into both of these groups. This speaks to the porous nature of the boundaries between groups (employees, for instance, may be integral to the success of efforts both in the community and in achieving a better market position).

INNOVATION IN AND FOR SUSTAINABILITY

Table 1 arrays types of innovation along the columns; sustainability occupies the rows. The columns are numbered while the rows have been assigned letters to simplify referencing any one of the twelve cells (e.g., C2 refers to Process Innovation which intends to achieve employee-related social sustainability). In much of what follows, we will discuss sustainability strategies that can be associated with each of the three types of innovation. In doing so, we will illustrate how prominent firms such as Pepsico, Manpower, 3M, and others fit into the Innovation-Sustainability matrix as well as how an organization can better align its approach to innovation with its sustainability focus. The intent of the table, then, is to tailor an organization's innovation strategy so it can enhance environmental and social sustainability and/or pursue sustainability initiatives which constitute new-to-company or even new-to-world innovations.

		Innovation		
		1. Product	2. Process	3. Managerial
Environmental	A. Cost	Redesign for reuse, recycling; refurbish; minimize consumer and social lifecycle costs; use of smart devices; coordinate with suppliers and buyers	Adopt lean operations, redesign processes to lower emissions and material usage; supply chain audits; use of renewable energy; minimize water use	Vision and strategy to initiate and expand sustainability; structured and organic sharing; incentives for lowering material/ energy usage; culture of frugal thinking; persuasion of shareholders
	B. Differentiation	Enhancing customer value—educating customers about sustainability, energy saving appliances and consumables, locally-grown produce, etc.; application innovation	Use of non-toxic, low-waste materials in non-durables and packaging; use of lighter materials; minimize post-consumer waste	Transition from cost-based to differential sustainability; align capability, performance, and reputation
Social	C. Employee	Employee involvement in generating ideas that serve a higher purpose (healthier food products; serving low-income buyers; working with schools, charities, the arts; partnering with social enterprise)	Facilitate involvement of employees who are passionate about social causes; establish mechanisms and informal procedures	Management's example in giving voice to workers, reducing disparities and biases; being proactive in retraining workers whose jobs may be displaced by technology, trade, and shifting demand
	D. Community	Designing products to serve the poor (health care, sanitation, energy); bottom-of-pyramid; partnering with NGOs, SEs for more effective delivery	Create supportive ecosystem through partnerships with local organizations; skill training; scale up services for the poor	Develop long-term sustainability strategies that align societal need, firm competence, and employee interest; engage shareholders in these efforts

Table 1: Strategies for innovation in sustainability innovation.

ENVIRONMENTAL SUSTAINABILITY: COST REDUCTION

We begin with environmental sustainability strategies (top-left in Table 1). Lowering internal costs to achieve cost leadership (Porter, 1985) may benefit a firm but may come at the expense of the environment in the form of increased carbon emissions, usage of harmful materials, higher after-sales and post-consumer waste, and so on. We thus contend that social and consumers' life cycle costs (Amienyo, Doyle, Gerola, Santacatterina, & Azapagic, 2016), in addition to the costs incurred by the firm, need to be addressed. The environmental impact (A1 in Table 1) may be minimized while reducing costs by refurbishing products (e.g., laptops, phones) so that these can be reused; remanufacturing (e.g., cars) by replacing worn out parts; reusing (e.g., sending used clothing to poorer areas of the country or the world); and redesigning (as has already been done to some mobile phone models) for easier separation of recyclable parts (Nguyen, Stuchtey, & Zils, 2014; Reike, Vermeulen, & Witjes, 2018). Redesign may also increase sales and profits—General Electric, for instance, reduced the cost and price of ultrasound equipment by about 80% after reconfiguring it to cater to the needs of low-income countries. The firm then reworked the device further to make it portable at an even lower cost (Immelt, Govindarajan, & Trimble, 2009).

Lowering environmental costs *to society* would also be included in A1. An example would be dishwashers that require less water at lower temperatures, are more energy-efficient, and use detergents that do not result in pollution—while such products might cost more to purchase, their lifecycle costs to consumers and to society at large may turn out to be way below those of less expensive models. The expanding reach of the Internet of Things (in smart metering as well as home control devices such as the Nest) is another way—through it, product innovation helps reduce resource and energy use in society as a whole, making it a step in the direction of greater sustainability (Hargadon, 2015; Arias, Lueth, & Rastogi, 2018).

One of the more common strategies adopted by firms seeking cost leadership is attaining greater efficiencies through process innovation (A2), with investing in process R&D and lean manufacturing along with extracting increased efficiencies from the supply chain being some of the more frequently used approaches (The Economist, 2013). Environmental process innovation, however, goes beyond traditional approaches by targeting quantity and type of resource inputs used. Examples of strategies in this cell of the table are Interface's modular (floor) carpets,

which enable the replacement of only those segments with high-traffic (Anderson, 2009), and Novelis Aluminum's sharply diminished water consumption combined with its high aluminum recycling rate (Novelis, 2017).

Managerial innovation in A3 covers a wide range of actions by which organizations stimulate creativity. Examples include teams both formed by management and that arise organically (for developing new products and/or reducing wastage, for example) as well as the institution of mechanisms for sharing knowledge that involves similar technologies across the organization to achieve both economies of scale and scope. The intent of 3M's Technical Forums, for instance, is to share technologies across divisions. These periodic events ensure that sustainability in various forms gains widespread commitment as the firm embarks on a strategy of innovation for sustainability (Gunther, Adamo, & Feldman, 2010). As O'Sullivan and Dooley (2009) note, managerial innovation also includes investing in research and development to reduce lifecycle costs and wastage of materials during manufacture (thus facilitating A1 and A2), fostering a culture of sustainability by offering incentives (providing internal capital, for instance, to invest in employee-generated ideas with market potential), and leaders setting an example. A configuration of coordinated decentralization would thus help in generating new ideas which are then examined and disseminated. General Electric's Ecomagination group, for instance, was formed after it was revealed that various divisions were undertaking sustainability initiatives without sharing or leveraging new ideas. The group helped coordinate the company's diverse efforts toward deepening focus on sustainability and improving time to market (Chesbrough, 2012).

Managerial innovation, in terms of charting a direction (e.g., technology leadership versus followership) and with regard to initiatives (R&D-driven, market-driven, open innovation, benchmarking, building absorptive capacity, wide employee involvement), can not only determine how organizations may be best configured for innovation but also facilitate the pursuit of other types of innovation. As Camisón and Villar-López (2014) and Damanpour and Aravind (2012) stress, managerial innovation can be the driving force behind a firm's ability to develop new products/services, processes, applications, business models, and marketing approaches.

A word of caution: total costs for the firm may rise in the short term while environmental costs to consumers and to society at large are being reduced. It is possible, however, to lower even short-term costs if, as an article in Crespin (2012) notes, the initial focus is on the source of the bulk of emissions and/or of material usage (such as the supply chain).

ENVIRONMENTAL STRATEGIES: DIFFERENTIATION

Environmental differentiation strategies are designed to deliver value through sustainable solutions that appeal to customers even at higher prices. Examples of strategies in B1 are roof tiles that double as solar panels, restaurants that make use of vegetables which lack aesthetic appeal but not nutritional value, grocery stores that source organically grown food from local suppliers, windows and doors that reduce heating and cooling costs, and cars that are carbon neutral (e.g., electric) with complementary features (such as nationwide charging stations). Given that the success of differentiation strategies depends upon enhanced value as perceived by the user (consumer surplus), purveyors of such approaches also need to position sustainability as a key differentiator and employ a combination of facts, transparency, and certification to ensure that customers get the message ("educating" the customer) (Himmelfarb, 2015).

Pepsico's "Performance with Purpose" vision (Marcus, 2015: 237–240), in which the company embarked on a strategy aimed at developing healthier snacks and beverages, was intended to create a distinctive edge for the firm while anticipating possible regulatory action in the future even if it meant higher costs and lower margins in the short term. Henkel introduced enzymes into its detergent in an effort to lower water temperatures for laundry machines, thereby helping users reduce their energy and water bills. The firm's elimination of phosphates also helped minimize impact on aquifers (Loew, Clausen, Hall, Loft, & Braun, 2009). H&M's and Zara's sourcing of organic cotton from South Asia helps enhance sustainability while promoting the welfare of farmers, thereby differentiating these firms from their competitors (Emmanuel, 2015). Firms whose products are recyclable once their useful life is over and used as inputs for new products in a cradle-to-cradle cycle (Braungart & McDonough, 2002) are also positioned as environmental differentiators.

B1 is also home to application innovation or the search for new and alternative uses for already existing products and technologies, such as using electric cars to power buildings during those parts of the day when energy is expensive. Companies that use the same material for making a diverse range of products also employ this approach to innovation. They are able to innovate around a core technology, thereby minimizing wastage while building a reputation (e.g., W. L. Gore in fabrics, boots, and temperature-resistant industrial materials [Hobcraft, 2011]). The use of plastic bags and bottles in road-building, for instance, exemplifies this kind of innovation in sustainable application.

Process innovation can enhance sustainability by changing how a product is made or how a service is delivered (B2). It goes beyond lean operations in emphasizing sustainability for all stages of the life cycle (including the supply chain and post-sale phases). Interface's elimination of harmful chemicals in carpets (Thorpe, 2014), Henkel's similar action for detergents (Loew et al., 2009), and the substitution of aluminum for steel in car bodies to reduce their weight and improve gas mileage (Novelis, 2017) are among the ways differentiation in sustainability is being implemented through process innovation.

Managerial innovation (B3) also embeds sustainability as a differentiating factor. Setting a strategic direction and vision for the firm's stance on product innovation (e.g., industry leader, quick follower, low cost imitator) and following that up with resource allocation (investing in product R&D, creating social capital, fostering grassroots commitment to sustainable actions) are integral to managing new ideas for sustainability. Whole Foods, for instance, established standards for organic food that exceeded industry benchmarks (in part by banning nearly eighty ingredients from its shelves) while attempting to source more local produce (McLaughlin & Martin, 2009; Marcus, 2015: 284–286). For firms like 3M, supporting and funding viable ideas in an open atmosphere where new opportunities and solutions are constantly being sought is one way to facilitate and enable more innovative efforts in general and more recently in sustainability. Resource and emission constraints, among other factors, are integral to 3M's innovation strategies. The firm sets ambitious goals that encompass the usage of sustainable materials as well as the reduction of carbon emissions and water usage while helping customers optimize resource inputs and energy expended (3M, 2018).

For a firm seeking to stake out a competitive advantage in sustainability, the message has to be clear that the company values sustainable action as the best approach for satisfying critical stakeholders such as customers, shareholders, suppliers, and employees. Moreover, in case some stakeholders like customers and shareholders are reluctant to accept the need for and value of such a strategic trajectory, part of the managerial innovation process lies, as Mackey and Sisodia (2013) suggest, in persuading these constituents about the long-term benefits of a sustainable strategy (e.g., decreased lifecycle costs, health benefits, etc. for customers; avoidance of future risks, likelihood of higher profits after an initial spike in costs, etc. for shareholders). This is especially important in countries where regulations concerning environmental issues are not so stringent or are being dismantled. Obtaining the buy-in of critical stakeholders, particularly customers, shareholders, and employees, is as important as adopting environmentally-friendly initiatives. As is the case with creating a distinctive position through any competency (quality, lead time, safety, etc.), the *perception* created in the minds of relevant stakeholders can spell the difference between success and failure in sustainable innovation. Thus, while establishing a reputation for sustainability can help create an enduring competitive advantage, achieving a balance between reputation and true capability calls for managerial ingenuity. Indeed, as Marcus (2015: 286–292) notes, Walmart's success in getting dairy farmers to switch to low carbon feed for cattle and use methane digesters and in installing wind turbines and LED lighting (at considerable additional cost) speaks of a commitment to sustainable solutions that is communicated to its major stakeholders through its actions.

SOCIAL SUSTAINABILITY AND PRODUCT INNOVATION

In this section, we investigate how product innovation can be aligned with a firm's social sustainability (SS) strategies with regard to community and employees. Product innovation is instrumental in SS (C1, D1 in Table 1) when restaurants, for instance, recast their menus and recipes to incorporate locally-grown produce, thereby reaping environmental benefits while increasing the freshness and creativity of their offerings. Regional farmers and markets, in addition, also benefit from such actions (Mealey, 2018). Other efforts that lie at the nexus of product development and SS strategies (Radjou, Prabhu, & Ahuja, 2012) include Osram's (Loew et al., 2009) development of solar lamps for use in villages that lack electricity, General Electric's

redesigning of medical diagnostic equipment (cited earlier) to accommodate the budgets of poorer nations, and the use of "frugal engineering" (designing products from the ground up to make them more affordable for lower income segments of all societies).

Businesses that extend their product range into the social arena (such as commercial banks that enter the market for microcredit) and companies that develop products aimed at lower income populations are also combining market/community sustainability with product innovation. Included in the latter are bottom-of-the-pyramid strategies (which generate high volume, low margin sales) such as Hindustan Lever's effort aimed at reducing the incidence of diarrhea by developing and marketing affordable soaps for millions of low income families (Prahalad, 2005: 207–239). Pharmaceutical firms developing drugs to help vulnerable people even at the expense of profits (Boseley, 2012) is a relatively recent phenomenon exemplifying this approach to sustainability in the social sphere. Alliances with non-governmental organizations (NGOs) and social entrepreneurships (SEs) may also weave SS into the innovation fabric of corporations—examples include firms like Pfizer that sponsor SEs seeking to address imbalances in society in areas like sanitation (Ng, 2017) and other matters affecting the most vulnerable populations (e.g., food security, water scarcity, and climate disasters [Acumen, 2015]).

Employee involvement can also leverage delivery of social value to other stakeholders. In the product innovation examples cited earlier, for example, employee participation in developing and popularizing healthier snacks and drinks, implementing microcredit, working with schools, building homes, and delivering food to the homeless can enhance both program effectiveness as well as employee commitment and loyalty (Kim & Scullion, 2013). Employees may also be involved in the development of new products from which profits are used to provide loans for low income clients and invest in social enterprises, as is the case with Barclay's Social Innovation Facility (Barclays, n.d.).

SOCIAL SUSTAINABILITY AND PROCESS INNOVATION

In terms of increasing worker satisfaction and efficiency, SS initiatives can also be a part of process innovation (C2) especially when employees are active participants in making refurbishment, remanufacturing, and reuse strategies

function properly, as shown by Norton et al (2015). This would also bolster process innovation undertaken as part of environmental initiatives (A2). Giving employees a greater say in workplace decisions not only enhances employee commitment but also improves productivity.

With regard to process innovation for community-related initiatives, working with local entrepreneurs to develop network effects for emerging products (such as repairing wind farms or electric vehicles) is one way to enlist creative partners as well as foster community ecosystems (D2). Examples of corporate efforts to enlist process innovation in the service of society are companies engaged in fair trade practices such as Starbucks (Horovitz, 2015) and supermarkets sourcing locally grown produce (Whole Foods [Dewey, 2017]) as well as firms working to help communities that are experiencing employment reduction and/or a shortage of skills, as some of the technology giants are attempting to do (Upson, 2018). The Aravind Eye Hospital, established in Madurai, India, adopted a novel approach to putting process innovation to work in helping patients in danger of losing their eyesight. Having developed a process for needed surgery that enabled them to lower costs, the founders are able to provide free services to the poor that are subsidized by charging higher income individuals. The development of an intraocular lens at a fraction of the market price also bolstered their ability to help the indigent even further (Munshi, 2009: 34–52).

SOCIAL SUSTAINABILITY AND MANAGERIAL INNOVATION

Managerial ingenuity is critical to establishing a socially sustainable strategy (C3, D3) and keeping it in place over the long term. Consider Manpower, Inc., a Fortune 500 multinational engaged in finding skilled workers for companies across the globe. When a tsunami devastated parts of southern India in 2004, numerous firms offered to support relief efforts by providing funds to private- and government-run agencies. Manpower, however, launched its own initiative. It set up a facility in the heart of the devastated area with the goal of training people in skills that were needed in that part of the country and beyond. Trainers were recruited and given flexibility to decide which trades were most in demand. An alliance was formed with an NGO that had experience in the region, with local customs, and with the government. People received training for a number of occupations such as computer and cell phone repair, masonry, construction, and woodworking. Many

women enrolled, and it was the first time the majority of them had ever worked outside the home. Some of the products were offered for sale at the center (the goal being to make the centers self-supporting in three years) and trainees were often placed with Manpower's regular clients for whom the reputation of the firm was greatly enhanced. Moreover, a group of Manpower employees, including the regional manager, were involved with this endeavor which served to internalize the company's mission (Arogyaswamy & Elmer, 2010). As such, while Manpower was not entirely altruistic in this venture, it was being a good citizen by bringing the benefits of work and life skills to people in despair. It effectively embellished its reputation with local governments and its client base while offering its employees a sense of purpose higher than that of simply making more profit.

This formulation of a social sustainability strategy in which market, community wellbeing, and employee ideals converge is not uncommon. As detailed in IBM's (2018) Citizenship Report, for instance, IBM Health Corps works with health organizations using analytics and cognitive science to improve delivery of medical care, Safety Net provides IBM solutions for civic organizations, and P-tech helps veterans with software training. Unilever's Sustainable Living Plan, aimed at countering climate change as well as addressing social inequalities and the need to tackle poverty, is also a striking example of how corporate vision can guide innovation. It has been reported (Sustainable Brands, 2018) that brands integral to Unilever's Plan have become central to the firm's success, growing much faster than the rest of their products.

CONCLUSION

We have posited and argued, along with providing examples, in the preceding sections that corporations need to integrate ecological and social sustainability in their strategies as part of building a competitive advantage through innovation. One way to do so could be by identifying the type of innovation that best suits their needs. Herman Miller, for instance, a firm that was already invested in lean manufacturing, developed a focus on sustainability through process innovation (A2) by using recycled materials as inputs and building reusability into its finished products. The company eventually differentiated itself on that basis (B2) and transitioned to product innovation with a view toward differentiation (B1) by introducing a new line of accessories, furniture for home offices, illumination, and

so on while working with architects and interior decorators (Kackley, 2015; Herman Miller, 2018). Starting with a commitment to redesign products, extend their useful lives, and minimize total life cycle costs to consumers and society (A1) can thus help firms with no history of sustainability strategies achieve initial acceptance. Process enhancements (A2) may also facilitate such a transition.

The role of managerial innovation is critical in terms of providing a sense of direction, stimulating product and process innovation, motivating employees, and creating a culture and organizational configuration that is supportive of innovation focused on sustainability. It is well known that working toward a purpose higher than their own needs and the firm's material goals often inspires employees (Kim & Scullion, 2013). Initiatives toward sustainability in both its environmental and social forms could thus provide such a purpose if the company's actions are demonstrative of its stated intent.

Product and process innovation, however, lead inexorably to new technologies that often disrupt the workplace by requiring skill-sets radically different from the ones that some or many existing workers already possess. In such cases, we argue that it is incumbent on firms that are committed to social sustainability to take responsibility for the workplace security and on-the-job fulfilment of these employees. For instance, firms should not only develop strategies for profiting from market opportunities as new forms of product and process technology make their appearance. They should also consider simultaneously formulating plans for re-training employees to transition to the new technology. Indeed, relying on the free market or governments to take care of displaced workers as new methods are developed to increase productivity in the workplace (e.g., through automation and robotics) has, by and large, been less than adequate (Fadulu, 2018). It is time for corporations to play an expanded role in dealing with the changes sweeping society, changes which they have a played a leading role in bringing about. Microsoft (Microsoft News Center, 2017) has taken a step in this direction by forming an alliance with the Markle Foundation and investing $25.8 million to help workers acquire the digital skills they will need in the workplace of the future. The Royal Bank of Canada, meanwhile, has invested over $500 million in a multiyear project to prepare youth for the world of work in 2025. Involving young people to envision what they need to prepare for and using metrics to assess the accuracy of predictions and effectiveness of action plans (RBC, n.d.) are among the features of this initiative.

Other companies such as AT&T, Apple, Google, and IBM (as noted earlier) have also launched similar initiatives which stand at the confluence of the community-, employee-, and market-driven approaches to social sustainability. Consider AT&T's approach to this challenge: it is investing $1 billion to launch a massive retraining program after discovering that nearly half of its 250,000 employees lacked the necessary competencies to meet the company's digital needs over the next decade (and that many specializing in hardware would become redundant). While the rationale underlying this strategy is partly because training new employees would cost more, the main reason appears to be that a long-term, ongoing relationship with its own workforce would bolster morale and foster mutual loyalty (Caminiti, 2018).

Thus, while measures for both sustainability and innovation are needed to substantiate the connections hypothesized in this paper, the conceptual and normative approach adopted herein can be gainfully leveraged for conducting empirical work along the lines proposed. Considerable studies in the area of sustainability metrics have already been done by researchers such as Keeble, Topiol, and Berkeley (2003), Pissourios (2013), and Arogyaswamy (2018). The types of innovation delineated here, moreover, could be operationalized based on the works of authors such as Adams, Bessant, and Phelps (2006) and Alegre, Lapiedra, and Chiva (2006). Indeed, while some connections (e.g., cost reduction-environmental sustainability) might be relatively easier to establish compared to others (e.g., community sustainability-product innovation), the benefits in terms of lower emissions and material wastage as well as enhanced employee and community welfare can be tremendous.

We conclude with the observation that future repercussions of unrestrained innovation could be even more damaging. Husain (2017) notes that the nature and availability of work will shift radically as Artificial Narrow Intelligence based on deep learning (focused on goals set by humans such as the proliferation of drone deliveries, autonomous cars, and automated stock trading) becomes a taken-for-granted part of our lives. The social, cultural, and political impacts of innovations in the near term are likely to rival the environmental impact, concerns over which have already elicited widespread alarm and received wide publicity. The prospect of international cooperation, for instance, is likely to erode as more countries begin pursuing nationalist agendas, thereby fueling a race for accelerated growth driven by innovation. As Worthington (2018), Cederman (2019), and others have pointed

out, a rising tide of nationalist passion can result in the jeopardization of concerns for the environment, of pressing social needs, and of the observance of political norms. The need for corporations to act, which has been emphasized in this paper, has become even more imperative. Collaboration with governments, NGOs, and other civic institutions is required without a doubt for addressing the multiple threats posed by the acceleration of innovation to fuel economic growth. As the main driver of economic growth and change, however, the business firm may need to spearhead the effort to keep society on an even keel.

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DECISION SUPPORT SYSTEM FOR ROOFTOP SOLAR IN THE BRONX

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ABSTRACT

This paper proposes a decision support system for the economic and technical feasibility of operating distributed photovoltaics in Bronx, N.Y. Existing research shows that distributed generation (DG) is a more effective way of reengineering the electricity system to integrate more renewable sources compared to a centralized, fossil fuel-based system. The viability of decentralizing electricity production with solar, however, is location-dependent and does not achieve the economies of scale that centralized systems enjoy. To determine the economic feasibility of DG with photovoltaics at a regional level, the system proposed here accounts for the relative cost to consumers and supply of electricity from the grid based on a framework developed by the National Renewable Energy Laboratory. The variables that were considered include regional demand, space capacity, fixed and variable costs to consumers, supply costs, and existing government support programs. Thus, drawing on data reported by the New York City government and other sources, this paper found that rooftop solar is economically feasible with existing government support programs and can reduce overall emissions despite being unable to meet the Bronx's peak demand. The proposed system can therefore be adopted and used by public and/or private local decision-makers from other similar locations.

KEYWORDS

solar energy; decision support system; business intelligence; economic feasibility; technical feasibility; distributed generation

INTRODUCTION

The world's energy system has attracted international attention because of its universal impact on and criticality for the future of human civilization. Global trends such as urbanization, industrialization, and digitalization are inherently connected to innovations in energy that reshape the landscape of its demand (World Economic Forum, 2017). Yet technological advancements in energy production and consumption could support such changes—according to a Bloomberg New Energy Finance study, for example, solar energy can economically meet half of the world's electric power needs by 2025. New sources of capital, in addition, have also made energy innovation possible. Private investors, for instance—rather than traditional government or public market support—have invested $200 billion in the energy sector over the last five years (World Economic Forum, 2017).

Much of the infrastructure we take for granted, however, is aging at the same time. According to the New York State Energy Research & Development Authority (NYSERDA), 84% of New York State's electric grid infrastructure predates the 1980s. Current power sources may even be slated for shutdown, such as the Indian Point nuclear plant which supplies 25% of New York City's electricity. It is scheduled to be closed down in 2021 (McGeehan, 2017).

In response to these trends and environmental concerns associated with fossil fuels, many state and federal governments have set lofty targets for power diversification and greenhouse gas reduction. They also offer financial incentives to encourage residents and businesses to reach these goals; such incentives, by some accounts, could, for example, offset the installation costs of solar by upwards of 90% (EcoMen Solar, 2016). These programs, therefore, suggest both a supportive political environment for renewables and an opportunity for investment.

The cost of renewable energy technology is declining as well. The National Renewable Energy Lab (NREL), for example, reported that the installation cost of both residential and commercial solar decreased by 240% from 2009 to 2016 (Brown et al., 2016). Renewable power assets, including solar, are nearing price parity with current fossil fuel-based sources as a result, and they will be cheaper than fossil fuels and offer significant investment opportunities that also address structural and environmental concerns if this trend continues. As we stand, therefore, at this convergence of trends in the energy sector, it is critical to understand available technologies in energy as well as the investment opportunities related to them.

One promising technological direction is distributed generation (DG). As defined by the Federal Energy Regulatory Commission (FERC), distributed generation is a "variety of technologies that generate electricity at or near where it will be used.… Distributed generation may serve a single structure, such as a home or business, or it may be part of a microgrid (a smaller grid that is also tied into the larger electricity delivery system)…." Unlike our current centralized system which relies on few inputs and long distances between producer and consumer, distributed generation is decentralized, with many inputs that are local to the point of consumption. Figure 1 in Farrell (2011) compares centralized and decentralized power systems.

Distributed generation as a concept is not new—energy production was decentralized even before the 20th century. Utility providers who served locally, however, began to realize the economies of scale that were achievable by centralizing their delivery mechanisms. This eventually led to our centralized system in use today (EPA, n.d.). Decentralizing energy production today, then, would require significant investment given the economies of scale achieved by centralized systems. Nevertheless, DG offers two primary benefits: improved reliability due to localization and increased potential for integration of renewables into the energy supply. According to the U.S. Energy Information Administration, nearly 10% of energy produced is lost in transmission. DG mitigates these losses significantly by reducing transmission distance; energy lost in transmission is thereby reduced given that power sources are closer to the point of consumption. DG also increases the potential for incorporating renewable power sources into the energy supply. There are more opportunities to integrate solar, wind, or hydroelectric given a wider range of possible energy sources (U.S. Department of Energy, 2007).

Distributed generation with solar in particular could address a number of energy concerns and provide an investment opportunity. The actual feasibility and potential of distributed solar, however, is highly location dependent. Critical determinants vary due to weather patterns, solar radiation, installation costs, and electricity prices. Assessments are required at the regional level to determine with accuracy whether or not distributed solar is feasible and if other sources should be explored.

The objectives of this study are twofold. First, it seeks to create a model that combines technical and economic feasibility concerns, one that can provide investors and policymakers with insight into the costs and benefits of installing distributed solar on a regional level. Technical feasibility accounts for real-world

geographic constraints and system performance while economic feasibility is the difference between the value of electricity that would have been consumed from the grid otherwise and the capital cost of installing the photovoltaic (PV) system (Brown et al., 2016). Second, this study seeks to apply this model to Bronx, N.Y. in an effort to determine the technical and economic feasibility of distributed solar in that borough. The key research question is, "Is operating distributed photovoltaics technically and economically feasible in the Bronx?"

This study focuses on grid-connected, distributed photovoltaics (DPV). "Grid-connected" DPV means that the electricity generated by solar panels is used by the building and any surplus is sent into the grid; this surplus electricity can then be used by any other consumer. Thus, unlike stand-alone configurations, grid-connected systems rarely include storage (Blair et al., 2014). Grid-connected, moreover, means that the system owner's utilities will not be free. Demand charges will remain because the system relies on grid infrastructure; supply charges, however, will be zero (CUNY, n.d.).

"Distributed" refers to rooftop systems—space for ground-mounted distributed systems was not accounted for given that the area of study was in a dense urban setting. "Photovoltaics" means that solar energy rather than solar thermal, which generates heat, is used for electricity production. The scope of this study does not include other types of DG technologies such as wind, hydroelectric, biomass, or utility-scale PV. Finally, this study considers these factors on a local level such as that of a municipality or borough. It is not intended for assessments of entire nations or individual properties.

While the body of knowledge regarding DPV is significant (see Literature Review below), there are many gaps to be addressed. This study tackles two: 1) there is no model that ties technical capacity with cost estimates at a regional level, and 2) there are no studies of this kind on the Bronx, or on any another large urban area for that matter.

For the first gap, tying technical feasibility with cost estimates, there are no studies or models that calculate installation costs based on estimated system parameters and output beyond single properties. Proving the necessary energy and economic efficiency for regional investment, therefore, is an open research topic.

This paper seeks to close this gap to obtain a more comprehensive understanding of the value of investing in DPV on a regional level.

Second, there are no studies of DPV potential in the Bronx or a large urban area. A focused, regional study is thus required to understand rooftop solar potential in a borough like the Bronx. The determinants of technical and economic feasibility—rooftop availability, solar radiation, installation costs, government policies, and electricity prices, for instance—are highly location-dependent. As such, while many other sites have not been assessed, the Bronx was chosen because it hosts a mix of residential and commercial spaces and is an example of a dense urban area.

LITERATURE REVIEW

The body of knowledge regarding distributed generation, photovoltaics, and the economics of renewables has been growing rapidly through public, academic, and private research, particularly since the energy crisis of the 1970s (Sullivan, Cannon, Burton, Johnson, & White, 2014). To understand the current state of these domains, this literature review was conducted in four parts (the structure is shown in Figure 1): 1) affirming the necessity and relevance of renewables for our energy system; 2) validating the technical feasibility and availability of DPV technology; 3) current models for technical and economic assessment of renewables; and 4) existing studies of regional solar assessment.

Figure 1: Structure of literature review.

Trends in the Energy Sector and the Importance of Renewables

The World Economic Forum report (2017) sought to identify global trends, possible "game changers," and implications in the world's energy system. These trends included urbanization, technology cost reductions, advancements in materials, and increased socio-political commitment to the environment, all of which could transform how energy is produced and consumed, such as in advanced energy acceleration and system fragmentation. Such changes have implications for business, government, and society, necessitating new strategies, business models, and private-public collaboration. Moreover, the report placed renewables, and specifically decentralized energy, firmly at the top of global energy priorities. Indeed, while solar was one of many technologies discussed, the findings in the report affirmed DPV's relevance for further research and understanding of implementation potential in existing urban infrastructure.

Pérez-Arriaga et al. (2016) sought to address several drivers of change in power systems, including the growth of renewable energy sources, efforts to decarbonize the energy system, and the increasing interconnectedness of critical infrastructure such as transportation and communications. Four key areas of research were developed: 1) understanding how distributed energy sources affect the operation of power systems, 2) a framework for efficient market design, 3) competition between centralized and distributed resources, and 4) a policy toolkit for the future power system. Data for this analysis was collected from academic and industry publications rather than from proprietary measurements. The study expressed the importance and relevance of distributed generation for the power system of the future. Finally, this collaborative research among 23 organizations confirmed the validity and influence of renewable energy sources already evident in today's power system.

Sullivan et al. (2014) offered a high-level overview of distributed generation's potential economic benefits for both commercial and industrial end users. The paper described how and why DG has grown since the 1970s due to federal incentives, corporate green efforts, and declining installation costs. It also discussed ways in which DG is becoming more viable for commercial end users, including the leasing of space to third-party operators and new financing options. Ultimately, as the writers argue, DG will continue to grow in relevance for corporate investments because it can create opportunities for lower energy bills, tax credits, improved reliability, and product differentiation through environmentally conscious practices.

Technical Feasibility of Distributed Photovoltaics

Gagnon et al. (2016) quantified the potential output of rooftop solar systems in the continental United States. The study employed rigorous geospatial data and statistical analysis to determine an upper bound of deployment, and estimated that energy generation based on the suitability of small, medium, and large buildings could meet 40% of total national electricity demand with a total technical potential of 1,119 gigawatts. The report thus established that individual systems with existing PV technology could, when aggregated, technically meet a significant portion of U.S. electricity demand. The researchers acknowledged, however, that integrating such a significant quantity of DPV would require a flexible grid and supporting infrastructure, the feasibility of which they did not determine.

Optimal Energy Inc. et al. (2014) detailed the efficiency in adopting renewable energy technologies in New York State. The study took account of many technologies, including biomass, hydro, wind, and solar, and how they might relate in the state's energy portfolio over the next 10 to 20 years. Considering solar in particular, the data used shows the amount of solar radiation hitting New York State as being more than 1,200 times the state's annual electricity consumption. However, due to obvious limitations such as space availability, technical efficiency, and saturation of solar on the grid, solar can provide only 13% of New York State's electricity by 2030. Nevertheless, the researchers concluded that significant energy efficiency exists for solar given available technology during the study period and that pursuing this cost-effective clean energy could result in long-term net benefits for the state.

The U.K. OFGEM report (2007) was conducted by the British Office of Gas and Electricity Markets to address two long-term energy challenges: 1) reducing carbon dioxide emissions to tackle climate change and 2) securing clean and affordable energy to reduce dependence on imported fuel. To address carbon emission reduction, the researchers looked into the potential benefits of a decentralized energy supply. The study reviewed the key barriers to distributed generation, including cost, lack of information, complexities in the energy market, and regulatory barriers. The agency then concluded that distributed generation was an effective response to the energy challenges and recommended that the U.K. implement carbon pricing to increase the competitiveness of DG, which at the time accounted for only 10% of Britain's energy supply.

Existing Models of Cost Assessment

The U.S. Department of Energy and the National Renewable Energy Laboratory created the System Advisor Model (SAM) to offer performance and financial models designed to facilitate decision-making for stakeholders in the renewable energy industry (Blair et al., 2014). It consists of a myriad of verified models that simulate electric power generation for grid-connected systems. Users create a SAM file by choosing the appropriate technology (PV, solar, wind, or biomass) and model which SAM will then auto-populate with default input variables that can be modified depending on location, equipment used, installation costs, financial incentives, and assumptions. Users can then run simulations based on these inputs and analyze the results.

As a continuation of NREL's benchmarking efforts, Fu et al. (2016) measured the installation costs of PV systems in the United States. The methodology was described as "bottom-up" accounting for all system costs incurred during installation of residential, commercial, and utility-scale systems, and has been used by state or regional agencies such as NYSERDA (Industrial Economics, 2017) to estimate costs specific to their territory. All costs were based on the national average sale price, meaning estimates would have included the profit margins of the installer or developer; these averages were then weighted by each state's installed capacity. Based on the study's results, costs for all three system types were shown to be on the decline when compared to other benchmarking reports since 2009; soft costs, however, which include permit acquisition, inspection, and installation labor, have been increasing. The installation costs of PV may therefore stagnate or even rise as hardware costs begin to plateau.

To determine the installation cost in dollars per watt, NYSERDA (Industrial Economics, 2017) estimated the balance-of-system costs (those not attributable to the PV panels, such as soft costs) of rooftop solar installations in New York State in 2016 and combined them with hard cost components determined in the NREL cost benchmark described above. The study separated cost estimates for residential and commercial systems by geographic area (Con Ed service territory, Long Island, and the rest of NY State). Data was collected from installers via a survey and cost estimates reflected the median weighted results according to the market share of respondents. Such data can thus be used as a relatively current cost estimate for installation in New York State and as a benchmark for assessing costs in the future.

Brown et al. (2016) sought to develop a consistent method for estimating economic potential across renewable technologies, including wind, utility and distributed PV, hydro, geothermal, and bio. The first step in the model was to estimate technical potential; here the researchers estimated achievable energy generation capacity and annual generation using geospatial data, although the model did not consider future technology innovations that could increase this potential electricity output. The technical potential for DPV in particular was first estimated based on available roof space followed by an estimate of capacity based on assumed system sizes for "typical" roofs. The second step was estimating economic potential which for DPV was considered to be the utility bill savings that exceeded the capital cost of installation. The cost modeling also took into account the value of tax incentives as well as of CO_2 emissions and health costs that were avoided. The results of the economic assessments, however, had not yet been published at the time of this writing. Nevertheless, the report provided a standard framework for assessing the technical and economic potential of DPV at a regional or national level. Future reports, by following the same system parameters and test cases, could also be benchmarked against this model.

Regional Assessments of DPV Potential

In quantifying the maximum technical potential of distributed PV on residential rooftops in Kailua Kona on Hawaii Island, Carl (2014) addressed three primary areas: 1) modeling solar radiation, 2) estimating rooftop area, and 3) calculating electricity potential from that solar radiation given the constraint of rooftop availability. The primary contribution of her study is a practical application of the variables required to calculate technical potential. Indeed, she used high resolution LiDAR data to estimate rooftop area and found that rooftop solar could provide 17% of the total electricity produced for the island, which, being subject to climate change and the nation's highest electricity rates, has made energy independence by 2030 a priority. Progressing toward such lofty goals, like those of many other regions, requires in-depth study of solar potential. Carl's study, however, did not tie cost data to these estimates, and neither did it draw any conclusions about the economic impacts of significant solar installations.

Wiginton et al. (2010) applied geographic information systems and estimated system parameters to determine the technical potential of rooftop solar in southeastern Ontario. The study also broke ground by modeling the relationship

between rooftop availability and population (70 m^2/capita) for use in regional policymaking. After calculating the available rooftop space, the researchers concluded that potential PV peak power capacity could be 157% of the region's peak power demand and meet 5% of total annual electricity demand. In response, therefore, to Ontario's renewable energy policies, this study aimed to offer deeper insight into the potential of rooftop solar in the hopes of facilitating financing schemes and formulating future policies. It provided a practical application of the variables needed to estimate the technical feasibility of rooftop solar at the regional level as well as a benchmark for cities at a similar latitude.

Romero-Hernandez et al. (2012) sought to understand the potential of solar in Mexico's northern border states; they wanted, in particular, to determine the economic sense of investing in it given the country's intense solar radiation. The researchers, however, reported difficulty in obtaining comprehensive data which led to much of the study being qualitative and having the following observation: many obstacles remain despite the evolving market for solar in Mexico. On the institutional level, the government had not set specific targets for solar capacity and tax incentives were insufficient. There was little understanding of the financial development and funding of solar projects. Manufacturers reported that the Mexican market lacks sufficient know-how or technology. Consumers did not understand the potential benefits and cost savings; they were less likely to accept a long-term view on the investment, particularly in rural communities. Nevertheless, the researchers argued that these obstacles were worth addressing because of the immense job creation that can come from investments in solar in addition to the environmental benefits. They used three models to estimate job creation as a function of dollars spent or megawatts installed. The study's conclusions thus reinforced the potential benefits—if related obstacles are addressed—of residential and large-scale solar power generation. They shed light on the many facets affecting the feasibility of solar as a power source.

Considering technical, economic, and legal perspectives, Johansson and Karlsson (2015) investigated the economic feasibility of solar in Swedish office buildings. They used a case study approach instead of performing a regional assessment, measuring data for five office buildings and analyzing the electricity load, appropriate system configurations, and electricity output for each. This data was then matched with economic conditions to test the profitability of each configuration. Results showed

that investment in PV can be profitable given the right technical, economic, and legal conditions. The profitable system configurations determined in this study, which is somewhere between a full site and a regional assessment, could thus be assumed on a regional scale to estimate economic feasibility beyond a few properties.

Gerardi and Chin (2007) assessed the economic case for DG in Victoria, Australia. They considered all types of DG technologies, including solar, wind, and natural gas, along with two criteria: 1) "Is there a market failure which leads to an economically suboptimal level of distributed generation?", and 2) "Do the benefits of increasing the level of distributed generation through some market mechanism exceed the cost [of doing so]?" To respond to these questions, the researchers developed a model for the scope of DG using the following variables: capital cost of generation, fuel cost, operating cost, transmission losses, transmission costs, security of supply, and greenhouse gas emissions. Their study proved that while DG did not have the economies of scale that a centralized system enjoyed, it was advantageous within the Australian regulatory context because of carbon pricing. The predictions showed overall that electricity prices would drop by 5% and that emission of harmful gases would be substantially reduced.

Castillo et al. (2016) assessed the potential of solar power generation and created a suitability map of the European Union; in doing so, researchers applied multiple criteria to geographic data, including population distribution, topography, and proximity to the power grid. This methodology provided the variables needed for estimating suitability for solar on a regional scale. However, while the analysis was intended to facilitate fund allocation with a more accurate understanding of actual potential, no cost data were tied to the results.

METHODOLOGY

Hypotheses

The study tests two hypotheses:

Hypothesis 1: Distributed photovoltaics cannot fully meet the Bronx's energy demand without additional means of production. Based on the literature review, rooftop solar is not expected to meet all of the Bronx's energy demands. Brown et al. (2016),

Optimal Energy Inc. et al. (2014), and Gerardi and Chin (2007) all discovered that solar can provide only a portion and never 100% of electricity needed. Energy from the sun, in addition, is intermittent and not easily stored (Brown et al., 2016). It is expected, therefore, that rooftop solar can provide a significant portion of electricity demanded and that other sources will be needed to meet the remainder.

Hypothesis 2: A system of distributed photovoltaics is economically feasible in the Bronx given existing government support programs and policies. U.K. OFGEM (2007), Sullivan et al. (2014), and World Economic Forum (2017) conclude that DPV technology is becoming less expensive and that utility bill savings can offset installation costs. Investing in installations can also have a positive net present value given that solar panels require little maintenance. All these studies, however, assume that existing government support programs will incentivize and defray costs. It is expected, therefore, that the same will hold true in the Bronx. Rooftop solar installations will thus be profitable investments given existing financial support from the government.

Overview of Research Design

To test these hypotheses, the research design analyzed three areas: resource, technical, and economic potential. This framework is a modified version of that employed by NREL (Brown et al., 2016) and is represented in Figure 2. Resource potential is the theoretical physical potential of the power source; in this case, it is how much power comes from the solar radiation hitting the Bronx. Technical potential builds on resource potential by taking into account given rooftop constraints and other system parameters to determine estimated system size and electricity output. Finally, economic potential refers to project implementation costs and savings from displaced electricity consumption. It helps determine whether or not savings exceed installation costs.

Economic potential can be defined in many ways; for this analysis, it is determined based on whether or not the value of electricity not consumed from the grid exceeds the capital cost of installing the PV system (Denholm, Margolis, Ong, & Roberts, 2009).

The area under study is Bronx, N.Y. The sole utility provider for the area is Consolidated Edison, Inc., commonly known as Con Ed. This study does not focus

on a specific sector and includes all buildings in the Bronx—residential, commercial, and industrial. It also does not consider the feasibility of DPV for New York City as a whole.

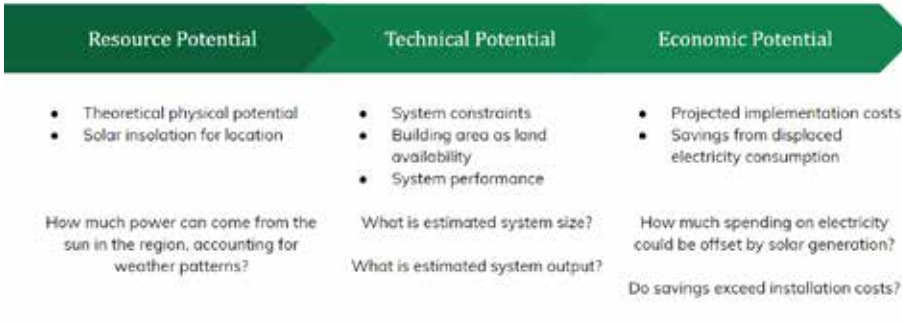

Figure 2: Overview of research design.

Sources for the Model Design

Based on the literature review, three existing sources were identified as drivers in designing the model used to analyze DPV potential in the Bronx. First, the NREL methodology (Brown et al., 2016) provided a general model for assessing technical and economic potential. It involved NREL's System Advisor Model (SAM) which accounts for weather patterns and system parameters to estimate power output (NREL, 2010). In addition, this study also uses the same test scenarios and standard system parameters employed by the NREL assessment.

Second, the NYSERDA balance-of-system study (Industrial Economics, 2017) provided the cost assessments that were collected from a survey of solar installers throughout New York State. That study reported baseline cost estimates of roof-mounted solar systems for different customer segments—both residential and commercial—and geographic areas, including the Con Ed service territory. These baseline cost estimates, in turn, provided the cost per watt of installation that was used to estimate the capital cost of installing DPV in the Bronx.

Third, the methodology employed by Wiginton et al. (2010) was an applied model for regional assessment that provided the specific variables needed for thorough analysis. That study also focused on the technical potential of rooftop solar in Ontario, Canada which is at a similar latitude with the Bronx; this meant that methods for solar estimates could be shared.

Description of the Decision Support System

Drawing on these three sources, a decision support system was designed for estimating the maximum system capacity, installation costs, electricity output, and savings of rooftop solar systems in the Bronx. It can be described in five parts as shown in Figure 3. First, it calculates the current system capacity that is needed to support the region. This can be used as a benchmark for comparing current and future states. Second, it estimates maximum energy production capacity given rooftop availability and NREL standards for system parameters. Third, the maximum system size combined with regional cost data and applicable government incentives determines the net cost of installation. Fourth, NREL's System Advisor Model estimates potential output by accounting for local weather patterns. Finally, savings from displaced energy are calculated using this estimated output. Economic feasibility is then determined by comparing savings and net installation costs over a multi-year basis.

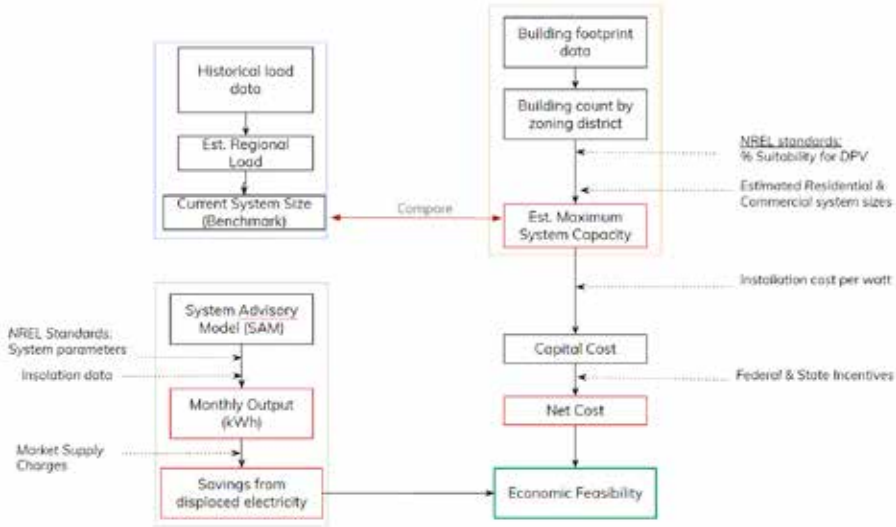

Figure 3: Decision support system design.

For this study, Bronx-specific data were used whenever these were available; estimates or values from other studies were utilized otherwise. The following subsections detail the specific factors in the decision support system and how the data were applied for the Bronx case study.

Current System Size. Load is the electricity use by end-users or customers as measured in MW (NY ISO, n.d.). The current system size is thus determined by historical load demand. This estimated load, in turn, can be used as a benchmark to compare the size of the current power system to that proposed in this study.

For the Bronx case study, current load for the Con Ed region was calculated from NY ISO's metrics of monthly wattage as generated by Con Ed (NY ISO, n.d.). The percentage of electricity supplied to the Bronx was then assumed to be based on the percentage of the population. According to the U.S. Census Bureau, the total population of the area which Con Ed services—New York City and Westchester County—was 9.5 million in 2017, with 15.3% or 1.4 million living in the Bronx. It is thus assumed that the Bronx requires an equivalent percent of the total load supplied by Con Ed.

Technical Feasibility: Maximum Solar Capacity. The technical feasibility of roof-mounted solar depends on rooftop availability. Due to scope, time, and resource constraints of this research and model, however, exact calculations of rooftop space could not be determined. Thus, for the purposes of this research, the building footprint was considered to be equivalent to rooftop area (other studies related to roof-mounted technologies, including Ackerman et al. [2012], have used this method). In accordance with standard NREL scenarios, it was assumed that buildings with a footprint of 100–5000 square feet could accommodate residential-grade systems while buildings with a footprint greater than 5000 square feet could accommodate commercial-grade installations (Brown et al., 2016). Residential systems average 8 kW in size (Brown et al., 2016) while commercial ones range from 36 to 170 kW in size since these systems apply to any building with a footprint greater than 5000 square feet (EIA, n.d.).

The amount of rooftop area for the Bronx was determined based on the NYC Department of Buildings shapefile of buildings greater than 400 square feet. The percentage of rooftop availability was therefore assumed to be 80% for residential and 50% for commercial buildings (Brown et al., 2016; EIA, n.d.). Furthermore, systems of 36 kW were assumed for all commercial buildings because buildings in the Bronx skew toward smaller areas.

Combining rooftop availability, the number of buildings available for rooftop solar, and system sizes for each building determines maximum system capacity. This value can then be applied to estimate electricity output and installation costs.

Technical Feasibility: Annual Electricity Output (kWh). Output from solar panels varies depending on location and time of year due to the intermittent nature of sunlight. A critical aspect, therefore, of the technical potential of DPV is solar insolation specific to the area of study. Thus, NREL's System Advisor Model, which calculates annual output from previously determined system capacity, uses computer models developed at NREL, Sandia National Laboratories, the University of Wisconsin, and other organizations (NREL, 2010) to represent the performance of renewable energy projects, models that require weather data and performance characteristics of physical equipment as inputs.

Weather data was imported from NREL's National Solar Radiation Database (NSRDB). Based on location latitude and longitude, the NSRDB is a serially complete collection of half-hourly values of meteorological data and the three most common measurements of solar radiation—global horizontal, direct normal, and diffuse horizontal irradiance.

Performance characteristics of physical equipment were kept consistent with those employed by the NREL analysis. Panels were assumed to have a DC to AC ratio of 1.2, an inverter efficiency of 96%, and a loss of 14% (Brown et al., 2016). These technical parameters, however, can be adjusted to analyze different system types or technological improvements.

With these inputs, SAM calculated the monthly and annual total system output in kWh. This was used to determine the value of electricity not consumed from the grid and the percentage of Bronx electricity demand that can be met with DPV.

Economic Feasibility: Capital Cost of Installation. The cost of installation is dependent on the system size as determined by rooftop availability and standard system parameters; this model specifically considers the cost per watt of installation, a standard measure used by NREL and NYSERDA. Table 1 details the cost breakdown for each system type. In accordance with the methodology employed at NREL, operation and maintenance costs are considered to be 0. Very little maintenance is

required once the panels are installed, and most of them are covered by a 20-year warranty in the event of damage (Brown et al., 2016).

NYSERDA Balance of System Cost Estimates – 2017 – Con Ed Service Territory

		Roof-mounted			
	Line Item	Residential	% of total	Commercial	% of total
Hardware & Materials	Module	$ 0.64	18%	$ 0.64	29%
	Inverter	$ 0.21	6%	$ 0.13	6%
	Structural BOS	$ 0.12	3%	$ 0.17	8%
	Electrical BOS	$ 0.25	7%	$ 0.16	7%
Soft Costs	Permitting, Zoning, Inspection	$ 0.24	7%	$ 0.06	3%
	Permit Fee	$ 0.05	1%	$ -	0%
	Interconnection	$ 0.05	1%	$ 0.02	1%
	Installation Labor	$ 0.39	11%	$ 0.42	19%
	Customer Acquisition	$ 0.50	14%	$ -	-
	Predevelopment Origination	$ -	0%	$ 0.26	12%
	Design & Engineering	$ -	0%	$ 0.03	1%
Other Elements	Supply Chain / Logistics	$ 0.27	7%	$ -	-
	Sales Tax	$ -	-	$ 0.04	2%
	Contingency	$ -	-	$ 0.06	3%
	Overhead	$ 0.47	13%	$ 0.19	9%
	Profit	$ 0.42	12%	$ 0.04	2%
	Total Costs	**$ 3.61**	100%	**$ 2.22**	100%
	Subtotal: Hardware costs	$ 1.22		$ 1.10	
	Subtotal: Soft Costs	$ 1.23		$ 0.79	
	Subtotal: Other BOS Elements	$ 1.16		$ 0.33	

Table 1: Balance-of-system costs—Con Ed service territory (2017).
Data source: NYSERDA (Industrial Economics, 2017).

The cost per watt of installation for the Bronx was $3.61 for residential and $2.22 for commercial systems. These values were based on NYSERDA (Industrial Economics, 2017) and the survey results of Con Ed service territory installers. Installation cost estimates included hardware and material costs, soft costs, and other balance-of-system cost elements.

Installation costs can also be offset by federal and state incentives, the value of which can be adjusted to reflect policies and programs applicable to the region of study. Incentives are offered in many forms, including rebates, tax exemptions, and grants, and specify eligible technologies, regions, and system sizes (NSRDB, 2018).

Solar installations in the Bronx can be eligible for Investment Tax Credit (ITC) and the NY-Sun Incentive Program. The federally-sponsored ITC applies to solar technologies, has no financial limit, and covers a maximum system size of 100 kW.

This means that each individual rooftop system considered in this study, being less than 100kW in size, qualifies for ITC. As of 2018, the ITC was valued at 30% of the installation cost but will decline to 10% by 2022 and expire in 2023 (U.S. Department of Energy, n.d.).

The second government incentive applied in this model is the NY-Sun Incentive Program which is sponsored by NYSERDA at the state level. These grants apply to grid-connected photovoltaics—making the systems considered for this study eligible—and are valued based on wattage installed. For the Con Ed service territory, the incentive is $0.40/watt and expires in 2023 (U.S. Department of Energy, n.d.).

The ITC and NY-Sun incentives were applied in this model because of regional and technical eligibility. The total cost of installation, however, will be allocated over a number of years given the impossibility of installing maximum potential capacity all at once. Thus, for this study, estimates for one (as a benchmark), ten, and 20 years will be conducted. Doing so will better reflect the impact of inflation and changing incentive values.

The total cost of solar technologies, however, has plateaued despite declining hardware costs. Soft costs, in fact, have increased in some cases. These trends are shown in Figure 4. Further cost reductions, therefore, were no longer considered for this analysis, although the system does allow changes to these parameters for further modeling.

Economic Feasibility: Value of Electricity Not Consumed from the Grid. Electricity is not free even after rooftop solar systems are installed; fixed demand charges still remain given that the system analyzed in this study relies on grid infrastructure (CUNY, n.d.). DPV could be economically feasible then if the value of offset electricity, multiplied by the amount of kilowatt hours produced annually by the system, exceeds the capital cost of installation as calculated above.

For the Bronx case study, Con Ed's 2016 Annual Report expressed variable supply charges that could be offset by 37% or 8 cents/kWh for properties with rooftop solar installations.

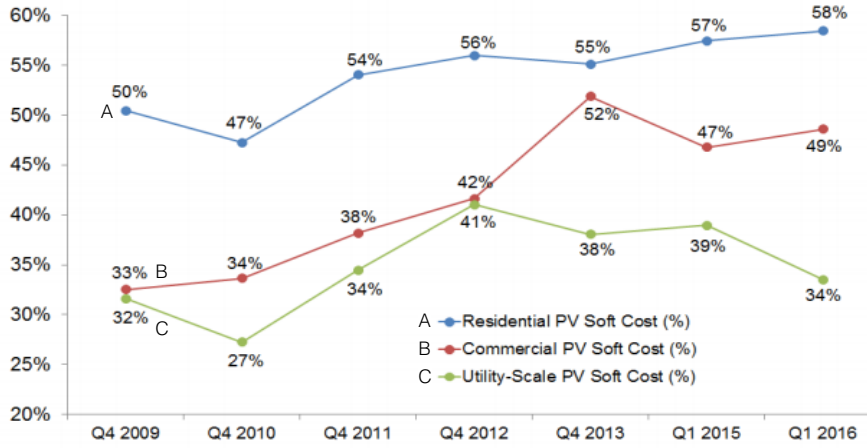

Figure 4: Trends in soft costs as a percentage of total cost for solar installations (2009–2016). Data source: Fu et al. (2016).

RESULTS AND DISCUSSION

The methodology described above was applied specifically to rooftop solar systems in Bronx, NY. The model relied on readily available data and on some assumptions that were consistent with NREL and NYSERDA studies. The results were divided into two stages: technical and economic potential. Technical potential involves the estimated maximum system capacity and annual electricity output. Those in turn drive the economic potential, which involves installation costs and accounting for financial incentives and electricity cost savings.

Technical Feasibility

Based on calculated rooftop availability and system parameters, rooftops in the Bronx can accommodate 748 megawatts of potential solar power production capacity. System size estimates were then applied to the System Advisor Model (SAM) as described above to determine electricity output, which itself depends on Bronx weather patterns, solar power's dependence on sunlight hours, system capacity, and technical parameters such as inverter efficiency. Annual output was thus estimated at 955 million kWh. Figure 5 shows monthly output, which varies greatly due to

weather patterns and solar radiation intensity. The maximum amount of electricity produced by the maximum installed solar capacity would be only 11% of annual electricity consumption in the Bronx (Con Ed, n.d.).

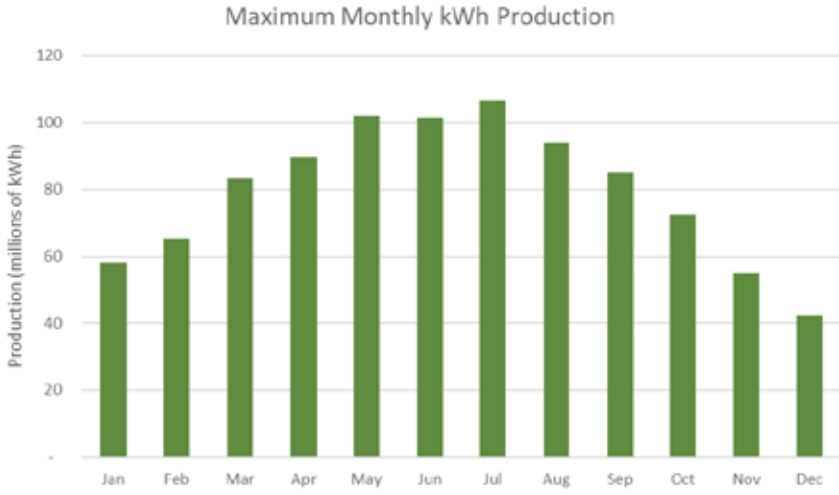

Figure 5: Monthly output from solar panels (kWh).

The space needed to support 750 MW of rooftop solar is also significant—panels would cover 16 km^2 while providing for only a small percentage of the Bronx's electricity needs. If solar was to provide all of the Bronx's electricity, panels would take up approximately 200 km^2. Thus, while a capacity of 750 MW is possible given current rooftop space and assumptions of availability, concerns with scale and space commitment cannot be discounted.

Nevertheless, rooftop solar could have capacity that is comparable to existing power sources even though electricity generation is intermittent. Compared, for instance, to monthly wattage generated by Con Edison (NY ISO, n.d.), the capacity from solar was at least 67% of system requirements for July and 94% at most in April. Indeed, the total capacity provided by rooftop solar remains the same despite seasonal fluctuations in capacity demand (this relationship is shown in Figure 6). The Bronx, for instance, requires approximately 900MW on average, with demand peaking at 2000 MW during a heat wave in July of 2013 as reported by Con Ed (Con Ed, 2017). The maximum capacity from rooftop solar, therefore, is comparable with what is required to support electricity consumption.

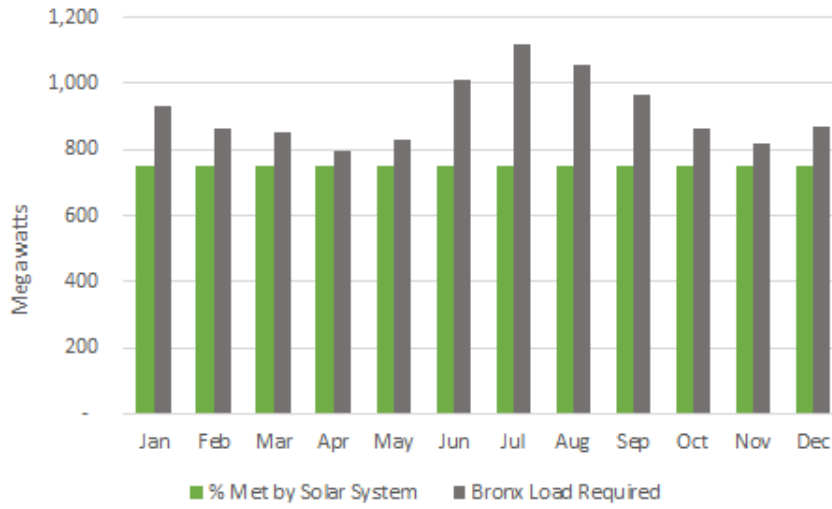

Figure 6: Maximum system capacity compared to capacity required monthly.

Economic Feasibility

As described in the methodology outlined above, estimated system capacity drives installation cost and estimated output drives electricity cost savings. Three scenarios were thus conducted to determine these costs: Scenario 1) implementation in one year, Scenario 2) implementation in ten years, and Scenario 3) implementation in 20 years. Each scenario begins in 2019 and accounts for installation costs, inflation, schedule of tax incentives, and annual cost savings. Table 2 details each scenario across three alternatives: with the current incentive schedule, without incentives, and if incentives continued at 2019 rates.

Scenario 1: Implementation in one year serves as a benchmark for the time value of money and the impact of delaying installation. Installation costs are estimated at $1.55 billion with a payback period of 20 years.

Scenario 2: Implementation over ten years would cost $2.46 billion and have a payback period of 37 years under the assumption that 10% of the maximum capacity is installed each year. Figure 7 shows the capital cost, net cost after incentives, and annual savings for this scenario. The net cost of installation is approximately 40% less than the capital cost until 2023 which is when both the ITC and NY-Sun

incentives are set to expire. Annual savings continue to increase as both system size and output do the same; these savings will continue at approximately $75 million after the maximum of 750 MW is installed by year ten and outweigh installation costs by year 37. Without these government incentives, payback would not occur until year 43; conversely, payback would occur within 28 years if government incentives maintained 2019 rates.

	Scenario 1	Scenario 2	Scenario 3
Length of Implementation	1 year	10 years	20 years
Government incentives as scheduled in 2019			
Total Install Cost	$1.55 billion	$2.46 billion	$2.92 billion
Payback Period	20 years	37 years	46 years
Without any government incentives			
Total Install Cost	$2.65 billion	$2.87 billion	$3.15 billion
Payback Period	35 years	43 years	49 years
Government incentives continuing at 2019 rates			
Total Install Cost	$1.55 billion	$1.71 billion	$1.91 billion
Payback Period	20 years	28 years	33 years

Table 2: Economic feasibility—3 scenarios.

Scenario 3: Implementation over 20 years would cost $2.96 billion and have a payback period of 46 years. This scenario assumes that 5% of the maximum system size is installed each year. Figure 8 shows the capital cost, net cost after incentives, and annual savings for this scenario. As with Scenario 2, installation costs are offset by government incentives until 2023. The value of incentives per year is lower, however, since it is dependent on watts installed. This scenario also has a longer payback period because it takes twice as long to install the full system and reach maximum savings potential. Without government incentives, payback would not occur until year 49; if government incentives maintained 2019 rates, payback would occur within 33 years.

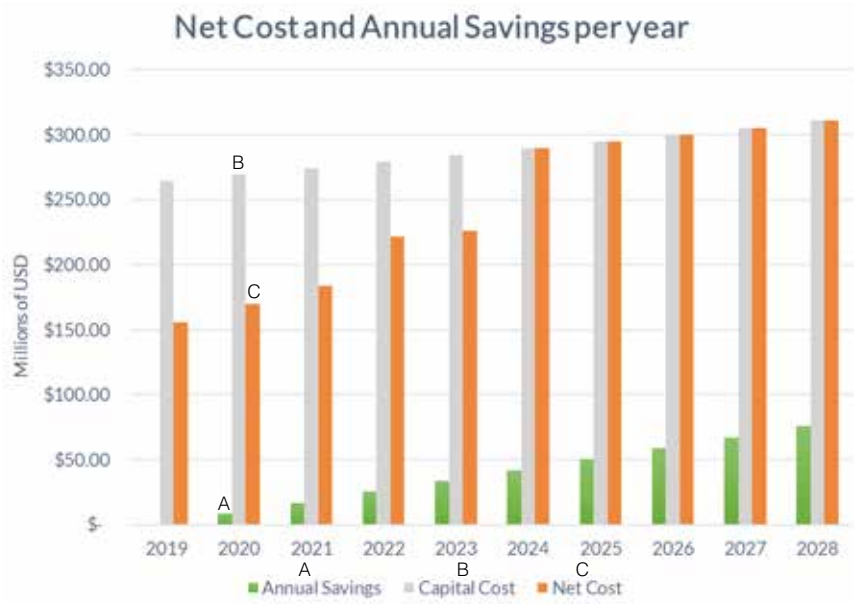

Figure 7: Scenario 2—10-year implementation.

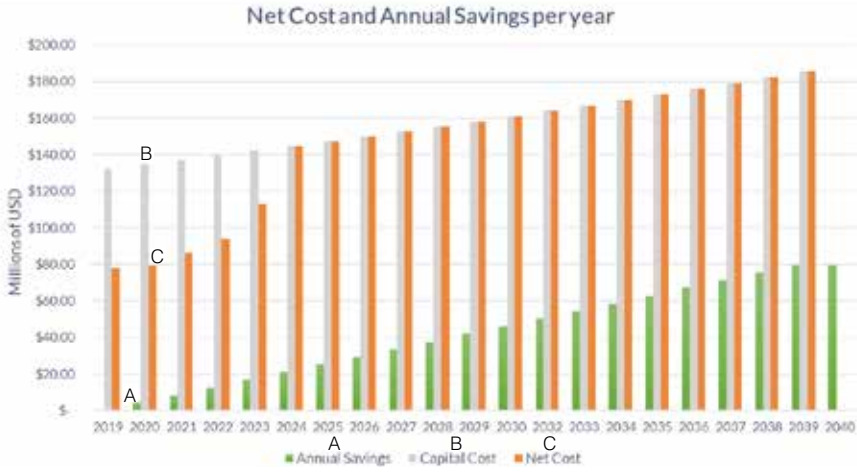

Figure 8: Scenario 3—20-year implementation.

All three scenarios will be profitable eventually. Economic feasibility thus depends on acceptance criteria. To tie these results to the two hypotheses posed:

Hypothesis 1: Distributed photovoltaics cannot fully meet the Bronx's energy demand without additional means of production. This hypothesis was proven to be true—rooftop solar could only meet 11% of Bronx electricity demand even with the maximum system size possible. Additional power sources would be required given the intermittency of solar power supply and the amount of electricity consumed in the Bronx.

Hypothesis 2: A system of distributed photovoltaics is economically feasible in the Bronx given existing government support programs and policies. The truth of this hypothesis is dependent on acceptance criteria. All three scenarios will be profitable eventually, when costs of electricity not consumed from the grid outweigh installation costs. Payback is possible even with the expiration of existing government support programs by 2023. Extending support programs, however, could shorten the payback period. The nuances and recommendations for improving economic feasibility are discussed below.

Discussion

Developing and maintaining a sustainable energy system is one of our biggest challenges (World Economic Forum, 2017). Yet the importance of renewable energies for reducing greenhouse gas emissions and securing power diversification cannot be ignored (Pérez-Arriaga et al., 2016). This study sought to contribute to our understanding of solar technology and its many facets—technical, economic, and environmental.

This study developed a decision support system for DPV on a regional level which was applied to the Bronx as a practical case. Using the system, it was determined that rooftop solar could not fully meet the Bronx's electricity demand yet could factor into a more diversified energy portfolio that leverages the benefits of DG and renewables. Indeed, the system calculated that rooftop solar could provide for 11% of the Bronx's electricity needs, a level comparable to national estimates in Brown et al. (2016) and state estimates in Optimal Energy Inc. et al. (2014). It is important to recognize, however, that other factors beyond those captured by currently available data could be critical in the installation and operation of rooftop solar.

One such factor is consumer psychology. DG relies on individuals to be the decision makers and adopt this technology, yet this system bases estimates on factors like availability of space and cannot capture property owner intention given the data available. It is still unclear whether or not property owners would be willing to invest in solar even with the prospect of saving on electricity bills. This may be a major obstacle in areas occupied primarily by renters—in the Bronx alone, only 20% of homes are owner-occupied and renters pay the electric bills (U.S. Census Bureau, n.d.). Indeed, the annual growth rate of installed rooftop solar capacity has declined in New York State (CUNY, n.d.; see Figure 9). This may indicate that the wave of early adopters has already passed. Incentive programs must continue, then, if regions deem rooftop solar to be critical for their future energy systems.

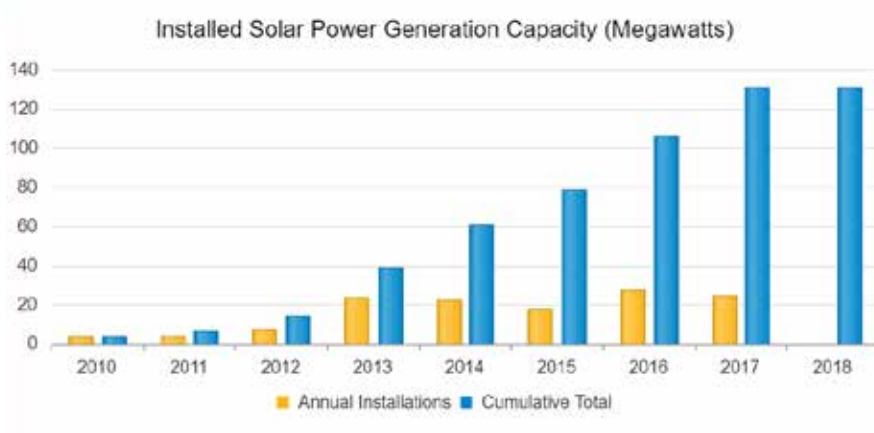

Figure 9: Installed solar power generation capacity in the Bronx (2010–2018). Data source: NY Solar Map (CUNY, n.d.).

Another factor is government support and related policies. The solar industry has been growing since the early 2000s due in part to government support programs that defray cost and incentivize installers (SEIA, n.d.). As shown in this study, current state and federal incentives can decrease installation costs by 40% in the Bronx. These programs, however, will expire after 2023, potentially making solar a negative investment by that time. To encourage more solar installations, policymakers have two options: they can either extend the support programs or implement a carbon tax. A carbon tax increases the financial cost of emissions for the user by imposing a $/ton tax on greenhouse gas emissions (Morris, 2013). Installing DPV and offsetting

fossil fuel consumption can negate this cost; indeed, Gerardi and Chin (2007) and Pérez-Arriaga et al. (2016) determined that DG can be economical if it is used to avoid or reduce a carbon tax. The United States currently does not impose a carbon tax but 40 other countries do (World Bank Group, 2016). Implementing a carbon tax, therefore, is one market instrument for incentivizing solar installers and potentially decreasing our carbon footprint at little public cost.

A third factor is limited understanding of the grid's ability to accommodate DG. As expressed in Gagnon et al. (2016), Optimal Energy Inc. et al. (2014), and U.K. OFGEM (2007), a significant quantity of rooftop solar requires a flexible grid and technically supportive infrastructure to operate. The cost of implementation would increase should technical upgrades be required, thereby decreasing feasibility. Upgrading infrastructure to support modern energy demands, however, may be inevitable given that the majority of grid infrastructure pre-dates the 1980s (Industrial Economics, 2017). Future research is thus necessary to determine how effective the current grid is at integrating DPV.

The proposed decision support system, while offering insight into the technical and economic feasibility of DPV, is not a comprehensive life cycle assessment or sustainability impact tool. Additional factors such as net carbon displacement and ecological impact can be included in future versions given that standard metrics are available. As such, even though solar technologies can reduce carbon emissions in comparison with fossil fuels, decision-makers ought to consider the sustainability trade-offs and identify the best renewables for their regions while factoring in weather patterns, resource availability, and end-of-life management concerns.

There is currently little formal or public reporting on existing installations in dense urban environments that can provide insight into qualitative factors. Our recommendation, then, for future study is a case study of a series of installations in the Bronx. One existing development is located at Hunts Point, the largest installation in New York City (Scarborough, 2014). In fact, additional plans to increase installed capacity on multi use buildings nearby have already been approved by the state (Level, 2016). Actual inputs and outputs can thus be measured given that these systems will be islanded together. Researchers will be able to observe the impact of private landownership, existing grid infrastructure, technical efficiency, and regulation. Having more of such detailed actual data from the Bronx would then enable an extension of the model designed in this study, refining its accuracy

and insights. Ultimately, we can encourage market participation and accelerate integration of renewables into our energy system by taking this research into practical applications and determining investment opportunities, such as rooftop solar in the Bronx.

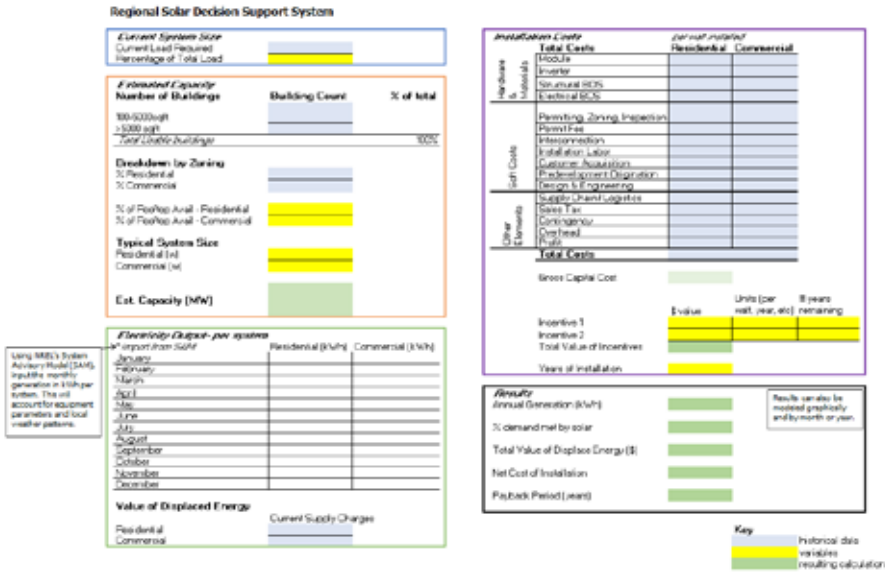

Figure 10: Screenshot of decision support system UI (user interface).

CONCLUDING REMARKS

A core thesis of this research study is that the promotion of sustainability and social innovation requires the design of systems that help policymakers and other stakeholders make informed, if not optimal, decisions. This research thus aims to contribute toward a more sustainable world (Stoner, 2013) by proposing and designing a decision support system that uses clear metrics and equations to determine the technical and economic feasibility of rooftop solar power generation in Bronx, NY. The model was designed by building on existing models used for regional assessment.

We also provided a deeper discussion of related issues as feasibility is a complex topic. Thus, while this study was able to estimate electricity generation and costs of rooftop solar, further research in this area is needed. In fact, the results of this study

make the case for deeper analysis of rooftop solar installations given that estimates show potential for offsetting fossil fuels and reducing electricity costs. We therefore propose that additional specific metrics can be applied to extend the model and improve its accuracy by tracking an existing case such as the Hunts Point site.

Lastly, we hope that other researchers may use our work as a starting point for designing decision support systems for solar energy in other cities or regions around the globe, thereby contributing toward a more sustainable world.

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USING MONTE CARLO SIMULATION AS A FINANCIAL MODELING TOOL TO SUPPORT SUSTAINABILITY EFFORTS OF A GOVERNMENT AGENCY

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ABSTRACT

The National Oceanic and Atmospheric Administration (NOAA) collects ecosystem data to support coastal resource conservation and management activities by studying stressors that impact estuaries such as the Chesapeake Bay, which is the largest in the United States. This paper seeks to help NOAA justify its existence and its budget by utilizing Monte Carlo simulation as a financial modeling tool, with such simulations providing insights on how to allocate identified resources. The results of the study offer an innovative method for helping government managers decide how much money to spend, what to spend it on, and how to acquire resources for the Chesapeake Bay Interpretive Buoy System. Moreover, this paper also demonstrates how an experiential project in graduate business education can be used to support sustainability efforts by addressing community-focused issues while improving student connection between theory and application at the same time.

KEYWORDS

environmental sustainability; Monte Carlo simulation;
financial modeling; government funding

PURPOSE OF THE STUDY

Experiential learning has become increasingly popular as a means for assisting students in the mastery of concepts and retention of content. Such is the case in graduate business education where students can aim to create value for their organizations by fulfilling course requirements framed in terms of addressing a company need. This paper discusses one such experiential learning project, one that supports efforts to protect and preserve the Chesapeake Bay, which produces 500 million pounds of seafood annually and supports two out of five major shipping ports in the North Atlantic. It is an attempt to assist the Chesapeake Bay Office, which is part of the National Marine Fisheries Service of the National Oceanic and Atmospheric Administration (NOAA), in recognizing the potential value that is present within the confines of the annual congressional budget allocation for the agency.

In 2016, the Association to Advance Collegiate Schools of Business (AACSB) formulated a collective vision for business education. They identified one of five drivers for change as business schools becoming enablers for global prosperity (AACSB International, 2016). Business is about more than just wealth creation; it is a vehicle for having an impact in the creation of a better, more sustainable world. The AACSB notes the need for business schools to innovate and for business schools and the business community to have a positive impact upon society.

> *The future calls for business schools to capitalize on academic strengths in order to grow and develop the rich space between theory and practice in ways that positively impact society. To do so, schools will need to pursue operational models and strategies that firmly position themselves at the intersection of industry and practice, as conveners and partners in the knowledge creation ecosystem rather than just suppliers.* (AACSB International, 2016)

The content taught in business schools, along with the research created by faculty in the academy, can thus be integrated to address global issues. This is not simply a nice idea—it is becoming the expectation of our students, the business community, and our accreditation organizations. Numerous researchers (Jamison, Hanushek, Jamison, & Woessmann, 2008; Kim, Tamborini, & Sakamoto, 2015; Tamborini, Kim, & Sakamoto, 2015) have described the importance of lifelong learning and demonstrated the value of education and training in sustaining a healthy economy.

In the context of this new perspective on business schools, it is imperative that graduate education today helps participants learn new skills that will aid them in making a difference both in their firms and in the world. The Assurance of Learning Standards conceptualized by AACSB focuses on learning outcomes, asking the question, "What will our students learn in our program?" (AACSB International, 2007). At Loyola University Maryland's Sellinger School of Business, the Professional's MBA is customizable and explicitly enables students to acquire a broader perspective of their organization as they gain real-world experience from visits to organizations and meetings with business leaders. Students will learn in an environment where they can explore new ways of thinking and acquire a deeper proficiency in the relationships that power successful organizations, helping them emerge as confident, competent leaders. This approach to graduate business education is value-centered and focuses on an ethical commitment that manifests itself in a series of learning goals designed to encourage student-based experiential learning.

Creating an often-new-to-the-organization means of deriving recommendations in support of a project, as is done by incorporating into research the available databases and tools that were learned in the classroom, is the goal behind pursuing student-based research projects within the curriculum. The experiential learning project discussed in this paper involves the development of a system that uses Monte Carlo simulation to justify the expense of the Chesapeake Bay Interpretive Buoy System (CBIBS; see http://buoybay.noaa.gov/) based on the value created by the data that was generated from the instrumented buoys.

DESIGN AND METHODOLOGY

The system that would become a financial modeling tool was developed in the context of a graduate course in finance (GB 719) the objectives of which were to 1) study capital budgeting models, 2) build a financial model, and 3) work with data from an existing organization. The course began with a review of the applications of financial decision tools such as payback period, net present value (NPV), internal rate of return (IRR), and profitability index before moving into learning new ones such as Monte Carlo simulation for valuation, a tool which had been previously used in other student case studies (Stretcher, 2015). Monte Carlo simulation allows students to build a tractable model that provides valuable information to the

decision maker. It can be used to determine how sensitive a system is to changes in variables or operating conditions as well as an optimal operating policy or distribution of resources (Winston, 1996). Company-specific projects are thus good platforms for applying Monte Carlo simulation since students will be using a new technique on familiar data—that gathered from within their firms or market areas. Research shows that student learning is enhanced when the work is relevant to their lives both inside and outside of the classroom (Kuh, 2016).

Projects are segmented into a series of deliverables to make them more manageable for students; increase the faculty member's familiarity with the student's company, market, and project as the semester progresses; and assure that the student is on track through feedback provided by the faculty member prior to a final submission.

The first deliverable for this project is an overview of the firm and market which, in this case, is complicated by the fact that NOAA's budget is set by Congress and has been declining in recent years.

PROJECT BACKGROUND

Founded in 1970, the National Oceanic and Atmospheric Administration (NOAA) is an agency of the U.S. Department of Commerce whose mission is to understand and predict changes in climate, weather, the oceans, and coasts; share that knowledge and information with others; and conserve and manage coastal and marine ecosystems and resources. Dedicated to the understanding and stewardship of the environment, NOAA has been a partner in the multi-state and multi-agency Chesapeake Bay Program which works to protect and restore the Chesapeake Bay through ecosystem science, coastal and living resource management, and environmental literacy. Their Chesapeake Bay Office (NCBO) supports NOAA's National Estuarine Research Reserves (NERRS) network, a system of 28 coastal sites designated for the protection and study of estuarine systems. NERRS has also developed partnerships within and outside of NOAA, such as with the National Parks Service and Environmental Protection Agency (EPA).

The NCBO fulfills its statutory mandate through multi-species fisheries research, habitat characterization and assessment, community engagement and outreach, and

coordination of NOAA activities under Executive Order (EO) 13508, Chesapeake Bay Protection and Restoration, which was issued in 2009. This EO states that the Chesapeake Bay Office shall "provide technical assistance on processes impacting the Chesapeake Bay system, its restoration and habitat protection; develop a strategy to meet the commitments of the Chesapeake Bay Agreement; and coordinate programs and activities impacting the Chesapeake Bay, including research and grants." The Agreement focuses on collaboration and coordination in watershed restoration and protection efforts.

The NCBO accomplishes its mission with personnel from several contractors as well as from NOAA's Fisheries Service, the National Ocean Service, and the National Environmental Satellite, Data, and Information Service.

NCBO's operations include the Chesapeake Bay Interpretive Buoy System (CBIBS) which was implemented in 2007. The CBIBS observation network provides users with information on wind speed and direction, wave measurements, dissolved oxygen, chlorophyll, and turbidity. These measurements provide the data necessary for improving marine forecasts which support commercial transportation, fishing, and recreational boating on the Chesapeake Bay. The growing database also provides information needed for monitoring the health of the Bay. Observations from the buoys are used in educational settings, and buoys mark locations along the National Park Service's Captain John Smith Chesapeake National Historic Trail (National Park Service, n.d.). Finally, software applications that allow users to obtain real-time weather and environmental information at any buoy location, such as wind speed, temperature, and wave height, are also available.

CBIBS supports watershed benefits such as fisheries and tourism which are estimated to be worth $4.6 billion annually in Maryland's Chesapeake Bay region (Phillips & McGee, 2014). To ensure high quality data, field technicians who understand the CBIBS system must be capable of completing diagnostics and repair in both the field and the laboratory. CBIBS buoys require monthly scheduled maintenance, semi-annual refurbishment, and an unpredictable amount of unscheduled maintenance (to repair or replace a broken cable or sensor, for example). Routine tasks include removing biofouling from buoy hulls and transducers, cleaning and replacing solar panels, and conducting mooring inspections, among others.

DETERMINATION OF ECONOMIC VALUE

Since there are no direct revenues associated with the purpose of this study, the value added by the agency's existence to constituents was estimated with the help of data gathered from various agencies and from previous studies that quantified the value of the agency's work.

Appropriations to the NCBO for each of the fiscal years from 2006 through 2016 totaled approximately $6,000,000. Figure 1 provides an estimate of this funding (NOAA Budget Office, n.d.). Buoys cost approximately $150,000 each (an operational CBIBS buoy deployed in the Severn River is pictured in Figure 2). Four buoys were lost due to ice damage during the winter of 2014–2015 (the impact of extreme winter weather on the Potomac Buoy is depicted in Figure 3). Estimated expenses are provided in Table 1.

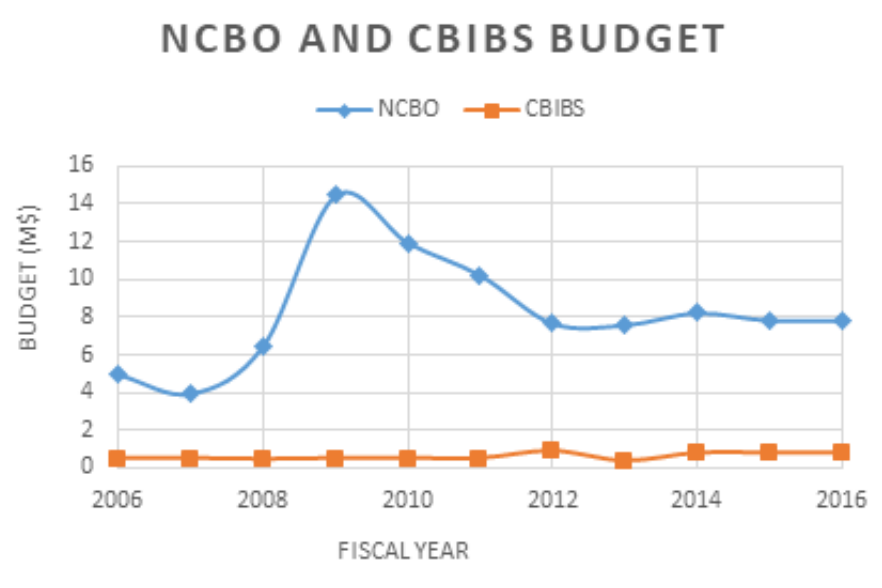


Figure 1: CBIBS budget fluctuations. While the CBIBS budget is steady at approximately $8 million per year, events such as collisions and severe weather can cause unbudgeted buoy destruction.

Figure 2: Annapolis CBIBS buoy deployed near the mouth of the Severn River. (Photo courtesy of C. Reid Nichols)

Figure 3: The impact of ice loading on a CBIBS buoy like this one in the Potomac River can confound measurements and destroy sensors. Ice floes can also drag the buoys out of position. (Photo courtesy of NOAA)

Item	Expenses	Remarks
Vessel Operations	$150,000	Ships such as the M/V *John C. Widener* are used to recover and redeploy buoys.
MARACOOS	$150,000	Data Management, Research & Development (R&D), Consultants
CRC	$300,000	R&D, Buoy Maintenance
Salaries	$200,000	NOAA and Consultants
NCBO may move various amounts of money to meet operational and maintenance needs as research and development is completed. Monies on the order of $20,000 per year, for example, may be available for new components and buoys as data management software is completed and vessel operations are reduced.		

Table 1: Estimated CBIBS expenses.

Based on the numbers provided by NCBO, there is an overall decline in budget which may be complicated by the need to maintain ageing CBIBS buoys. The system at present includes ten networked data collection buoys that are sited throughout the Bay. These buoys and their sensors require routine maintenance as well as the ability to procure supplies from manufacturers and/or vendors of buoy components. NCBO

as such maintains several contracts with multiple vendors who supply appropriate buoys, basic sensors, spare parts, and consumable materials. To control costs and ensure efficiency of maintenance as CBIBS expands, buoys added to the core system must be consistent to the greatest possible degree with the standard platform and complement of sensors currently in use.

Cost management also needs to consider contingency funding on an annual basis for at least one spare replacement buoy and an inventory of spare parts based on usage history. If the CBIBS program were to be downsized, buoys could be removed from the water and stored until repurposed or otherwise re-appropriated to another agency or organization (Wheeler, 2012). Some cost savings can be achieved by eliminating stations; others pertaining to salaries, equipment, website expenses, and facilities are fixed and cannot be scaled. These amount to an estimated $450,000 per year. The CBIBS program, on the other hand, may maintain its utility and operate for many years. According to the NCBO, for instance, financial resources to replace aging buoy components will be made available through more efficient use of vessel services and the elimination of a costly data management contract. Partners such as Virginia Commonwealth University (VCU) and Dominion Virginia Power might also deploy or donate similar instrumented buoys that can display observations through the CBIBS portal.

The presidential budget for fiscal year 2017 included $5.5 million for the coordination of NOAA programs and activities in the Chesapeake Bay. Activities included targeted restoration, protection, and monitoring of vital habitats and fishery resources; synthesizing and delivering scientific data to support the management of oysters, blue crab, striped bass, and other ecologically and commercially important species; and operating and maintaining CBIBS to deliver information about the Bay to the public. CBIBS as such continues to provide essential foundations or baseline data for NCBO operations and resultant reports.

We have used information obtained from U.S. Integrated Ocean Observing System (U.S. IOOS) studies in our analysis. Direct use values have been documented by NOAA and organizations such as the Chesapeake Bay Foundation (CBF). These data, information, and capabilities support the forecasting of harmful algae blooms, identification of hypoxia, monitoring of pathogens such as *Vibrio* bacteria, and essential infrastructure and processes for ecological forecasts. The NCBO, for example, provides CBIBS data to weather forecast offices and the National Data

Buoy Center (NDBC). The CBF uses the CBIBS system for both staff level scientific observation and analysis such as in the preparation of an annual Bay Report Card. Passive use values have been estimated—the CBF education program, for example, uses CBIBS field collected water quality parameters and CBIBS remotely sensed data in their Science, Technology, Engineering, and Mathematics (STEM) programs. CBIBS is introduced annually to over 1,000 secondary school students, their teachers, and principals, with the buoy system in particular allowing students to understand the concepts of stratification and eutrophication as it effects hypoxia. This is because the chlorophyll, bottom dissolved oxygen, and temperature sensors on some buoys augment data that students can collect from education vessel platforms such as the schooner *Lady Maryland*, Chesapeake Buyboats *Mildred Belle* and *Half Shell*, and Skipjacks *Sigsbee* and *Minnie V*.

Numerous authors (e.g., Altalo, 2006; Colgan, 2007; Kite-Powell, 2009; ERISS Corporation & The Maritime Alliance, 2016) have also looked at the U.S. IOOS or similar observatories and estimated the value of their observations for the benefit of the public. Requirements to safeguard lives and protect property drive the need for relevant observations and environmental information. These rely on environmental forecast information for operations in revenue forecasting and load management to infrastructure siting and supply chain management. Altalo (2006) points out that market economics is a major driver when there is a need for internalizing environmental externalities to reduce impact on operations. Systems such as CBIBS improve environmental forecasts and reduce risks, thereby increasing value for operations, and provide baseline data for regulators. A partial list of users that depend on or benefit from CBIBS is provided in Table 2.

The present study is the first one to look at the value of the CBIBS system as a whole. It addresses the broader question concerning the system's overall economic value for other government agencies, academia, industry, and the American public. The Maryland Department of Natural Resources, for example, received funding from NCBO to maintain buoys in Maryland waters while the Virginia Institute of Marine Sciences was also funded to maintain buoys in Virginia waters. U.S. IOOS funding for universities and NCBO funding for not-for-profit organizations such as the Chesapeake Research Consortium (CRC) also contribute to some basic research that is accomplished by university investigators. The Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS), a 501(c)3 corporation, has been funded to help integrate and display CBIBS data in a way that is consistent with

the U.S. IOOS. To support data integration with IOOS and acquire redundant server storage and access, CBIBS data are transmitted to servers maintained by the National Ocean Service, where processed data are inserted into a relational database and shared with MARACOOS and the NDBC. Data are quality controlled in accordance with the Quality Assurance of Real-Time Ocean Data (QARTOD) procedures that were developed by the NOAA U.S. IOOS Program, delivered to NDBC and appear on the Global Telecommunications Service within ten minutes of collection, and periodically transferred to the NOAA National Centers for Environmental Information for archiving. Finally, for profit companies such as Earth Resources Technology, Inc. (ERT) provide marine technicians to support many operational and maintenance tasks of CBIBS.

Such valuation research helps the Chesapeake Bay Program and organizations such as NCBO to define with accuracy and inventory the impact of observational systems such as CBIBS. It also provides an alternative to traditional discounted-cash-flow (DCF) analysis which, when used alone, may be biased against valuing projects such as CBIBS that are dependent on congressional appropriations. Rather than forecast cash flows budget year by budget year and then discount these static forecasts at the opportunity cost of capital, we will apply a Monte Carlo model, thereby allowing the reader to visualize inherent risks and their impact upon the Chesapeake Bay Program. McGinty (2016), for instance, describes how weather forecasters can use Monte Carlo simulations to compute for reliable probabilities of hurricane tracks and thus improve the skill of hurricane forecasting.

The allocation of resources is a key driver in CBIBS utility. This paper, moreover, also considers the policy implications if CBIBS were to be decommissioned.[1] A conservative salvage value for a CBIBS buoy—there are ten—is approximately $150,000 as estimated by Dr. Kilbourne. Abandonment of the system, however, would negatively impact other agencies such as the NOAA U.S. IOOS Program, U.S. Coast Guard (USCG), and the National Park Service (NPS) as well as organizations such as MARACOOS and the CBF that use CBIBS directly. NOAA funded research programs, such as the Coastal and Ocean Modeling Testbed for example, have also relied on CBIBS data (in this case, to assess an estuarine hypoxia model) (Luettich et al., 2017).

[1]The Chesapeake Bay Office of NOAA Fisheries and especially Dr. Byron Kilbourne who is the lead oceanographer responsible for CBIBS provided data and information that was essential to the completion of this study. Dr. Kilbourne identified the value drivers used therein, and his expertise assisted in the identification of the appropriate distribution to be used for each variable.

Sample Organizations	Sector/Program	Funder
WMO Integrated Global Observation System Region IV	Global Ocean Observing System	WMO
NDBC, Maryland Department of Natural Resources (MD DNR), USACE, USCG	Federal, State, and Local Government	Department of Defense, Department of Commerce, State of Maryland
University of Delaware, VCU, Virginia Institute of Marine Science (VIMS), University of Maryland Horn Point Environmental Laboratory and Chesapeake Biological Laboratory	Local Universities	NOAA, Southeastern Universities Research Association (SURA)
CBF, Chesapeake Research Consortium (CRC), Mid-Atlantic Regional Association Coastal Ocean Observing System (MARACOOS), SURA, U.S. Power Squadron	Non-Governmental Organizations	NOAA, State of Maryland, Private
AXYS Technologies, Caribbean Wind, LLC, Dominion Virginia Power, ERT, NORTEC, RPS Group, WET Labs, etc.	Industry	NOAA, Local Universities
Commercial Fishermen, Constellation Energy, Crowley Maritime Corporation, Kingfisher Environmental Services, Weather Channel, Weather Underground	Industry	NOAA, Private
Recreational Boaters	Power Boats, Work Boats, Sail Boats, Kayaks, and other water craft	Private

Table 2: CBIBS beneficiaries range from local recreational boaters to members of the World Meteorological Organization (WMO).

CBIBS may be partitioned into five main areas for the analysis of future value drivers: i) programs that focus on marine operations, ii) programs that focus on university research and development, iii) recreation opportunities for communities, iv) protection of natural environments and features that are important to communities, and v) use by industry. Each of these would be described in terms of cash flows. CBIBS, for instance, supports the development of research and new sensors that assist in NOAA's Ocean Acidification Programs as well as of models that support the Ecological Forecasting Roadmap. The program must also plan and budget for risks that require unscheduled maintenance. Indeed, CBIBS has already experienced ten catastrophic losses since 2007—five collisions with vessels, ice damage to four buoys, and vandalism of one buoy. Table 3 below highlights value drivers for the CBIBS program that impact the number of parameters that are measured, up time, usage, and data quality.

Impacts or risks to the budget such as deficits (or surpluses) need to be understood for CBIBS to remain viable. If NCBO takes in more money than it spends in a given year, for example, the result could be a surplus for enhancing the existing CBIBS. The fiscal year 2017 CBIBS budget, for instance, has reduced funding for vessel services and the development of a data management system. Such anticipated changes could free up approximately $100,000 which could be applied toward replacing aging CBIBS hardware or responding to system losses and contingencies. NOAA also requested $5.5M for the coordination of their programs and activities in the Chesapeake Bay region for 2017. It would seem then that programs such as CBIBS facilitate the transfer of funds, property, and services to the NOAA Chesapeake Bay Office from other federal agencies. We estimated that the transfers will not exceed $500,000 per year.

The declining NCBO and stable CBIBS budgets are depicted in Figure 4. Based on an R^2 of 0.003, there is no clear association between the two.

Buoy Location	Impact (Period of Operation)	Description
Susquehanna (S)	None (2008–2016)	Buoy is visible from locations along the Harford and Cecil County shorelines, including Havre de Grace's Concord Point and Promenade area.
Patapsco (SN)	2008, 2010 (2008–2016)	Buoy was struck by vessel, resulting in significant hull damage and flooded instruments. Buoy was vandalized.
Annapolis (AN)	2015 (2009–2016)	Buoy accumulated ice on superstructure and capsized in February 2016.
Upper Potomac (UP)	(2010–2016)	Buoy was impaled by carbon fiber object. There is a large hole in the hull. Buoy damage estimated at $30,000.
Gooses Reef (GR)	2015 (2010–2016)	Buoy accumulated ice on superstructure and capsized in February 2016. Owing to Hurricane Matthew damage, it flooded internally, resulting in low buoyancy which reduced resiliency of the hull. Buoy damage estimated at $30,000.
Potomac (PL)	2015 (2008–2016)	Buoy accumulated ice on superstructure and capsized in February 2016.
Stingray Point (SR)	None (2008–2016)	Located near Deltaville, VA and approximately a mile offshore.
York Spit (YS)	None (2016)	Buoy is located near Perrin, VA at the mouth of the York River. Maintenance activities involve the CBIBS field and technical team in collaboration with partners from NOAA Sanctuaries and the VIMS.
Jamestown (J)	2015 (2007–2016)	Buoy accumulated ice on superstructure and capsized in February.
First Landing (FL)	2008, 2010, 2012, 2016 (2011–2016)	Buoy struck by vessel and relocated; another relocation is planned. In October 2016, vessel collision damaged superstructure and meteorological sensors; internal flooding occurred during Hurricane Matthew. Buoy damage estimated at $50,000.

Table 3: Attribute descriptions—CBIBS. Buoys collect and report information for up to 37 meteorological and oceanographic parameters. Details were obtained from http://buoybay.noaa.gov/.

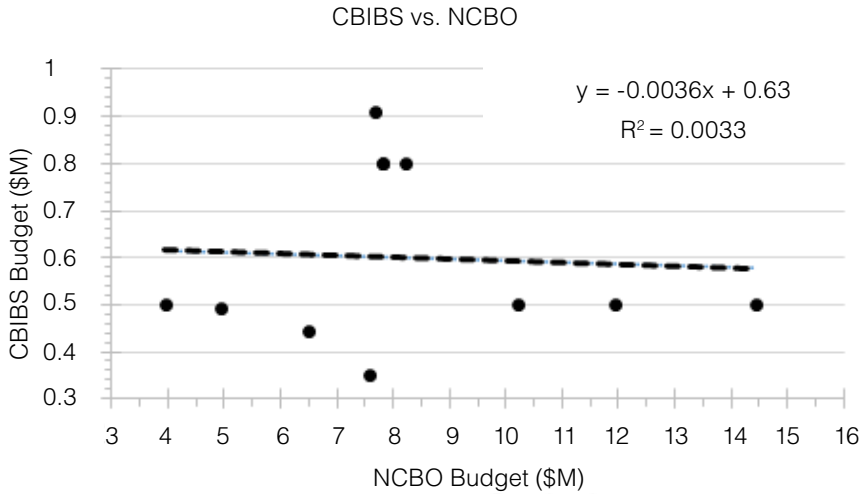


Figure 4: Budget graphic showing the correlation between the NCBO and CBIBS budgets.

FINANCIAL MODELING USING MONTE CARLO SIMULATION

For the Monte Carlo simulation, different types of distributions were reviewed, the best fit distribution was determined, and the data was inputted into the Monte Carlo model. The product used for running the simulation, @Risk Monte Carlo simulation software, contains more than 100 distributions for consideration in modeling variables. The distributions selected, and the rationale behind their selection, are discussed below.

> Monte Carlo simulation performs risk analysis by building models of possible results by substituting a range of values—a probability distribution—for any factor that has inherent uncertainty. It then calculates results over and over, each time using a different set of random values from the probability functions. Depending upon the number of uncertainties and the ranges specified for them, a Monte Carlo simulation could involve thousands or tens of thousands of recalculations before it is complete. Monte Carlo simulation produces distributions of possible outcome values.
>
> By using probability distributions, variables can have different probabilities of different outcomes occurring. Probability distributions are a much more realistic way of describing uncertainty in variables of a risk analysis.…

> During a Monte Carlo simulation, values are sampled at random from the input probability distributions. Each set of samples is called an iteration, and the resulting outcome from that sample is recorded. Monte Carlo simulation does this hundreds or thousands of times, and the result is a probability distribution of possible outcomes. In this way, Monte Carlo simulation provides a much more comprehensive view of what may happen. It tells you not only what could happen, but how likely it is to happen. (Palisade, n.d.)

The Monte Carlo simulation for this study required the development of scenarios that included assumptions about the value drivers and factors that are critical to CBIBS's success. These value drivers relate to usage of the system by universities, industries, other agencies, and the general public. Random inputs (within realistic limits) were used to model CBIBS's costs and produce probable outcomes of value. A quantitative model of CBIBS activities as well as a "transfer equation" based on NOAA-derived information were developed. Some of the value factors in the transfer equation were found to follow a normal distribution while others followed a triangular or uniform one.

Distribution parameters for each input (e.g., the mean and standard deviation for inputs that follow a normal distribution) were then determined. For the triangular distribution, the minimum, maximum, and mean variables were found through a review of historical data as well as by relying upon the expertise and experience of Dr. Kilbourne. Likewise, the minimum and maximum values for the variables in constant probability uniform distribution were determined using historical data as well as CBIBS's executive expertise.

The value drivers are characterized by relevant distributions. Procurement of spare parts and buoy components, for example, was modeled using a triangular distribution with minimum costs of $493,000 annually, most likely outflows of $800,000, and maximum costs of $1,400,000. This distribution and its parameters were determined by reviewing historical data as well as incorporating replacement costs; distribution was estimated using actual historical data ranging from a cost of components of $20,000 when no exceptional events occur to the loss of three buoys like that which occurred in 2015 with a replacement cost of $450,000.

Likewise, costs incurred by CBIBS were modeled as a triangular distribution based upon both historic costs and future projections. Buoy procurement is one example—the practice for CBIBS is to acquire buoys on a regular basis to replace worn or damaged units and have a small inventory of buoys and buoy parts

available. Given the lack of correlation between CBIBS's needs and NCBO's budgets (given that the budget is set by Congress), however, variables such as R&D expense, extended operations, and new products are funded based on remaining budgetary allotments available after costs of operations are covered and buoys are procured. These variables are also modeled using a uniform distribution.

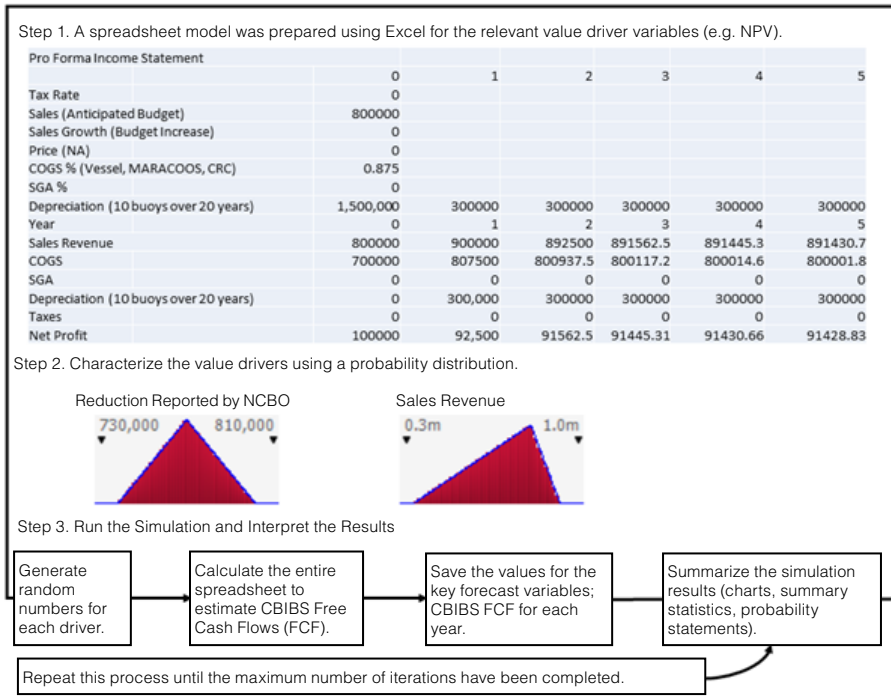


Figure 5: Monte Carlo Simulation flow diagram (adapted from Titman & Martin, 2016). The simulation was run with incomplete value drivers as a student exercise. The importance here is in the process of determining value for a public good such as CBIBS.

FINDINGS AND DISCUSSION

The *pro forma* cost of operating CBIBS resulted in an NPV of $24,307.44 and an IRR of 10% over the five-year period (2016–2020) of this study.[2] Variables that

[2]The Office of Management and Budget (OMB) has had a real discount rate of seven percent for public investment and regulatory analyses since 1992.

could be used by NCBO for budgeting were estimated using a simple Monte Carlo simulation based on historical trends and the following distributions for key variables (Table 4):

Variable	Expected Value	Distributional Assumption	
		Distribution	Parameter Range
Budget appropriations	$800,000	Triangular	$351,000 – $912,000
Costs	$770,000	Triangular	$740,000 – $800,000
Buoy procurement	$150,000	Uniform	$150,000 – $300,000
R&D	$200,000	Uniform	$200,000 – $1,000,000
Extended operations	$200,000	Uniform	$200,000 – $400,000
New products	$200,000	Uniform	$200,000 – $800,000

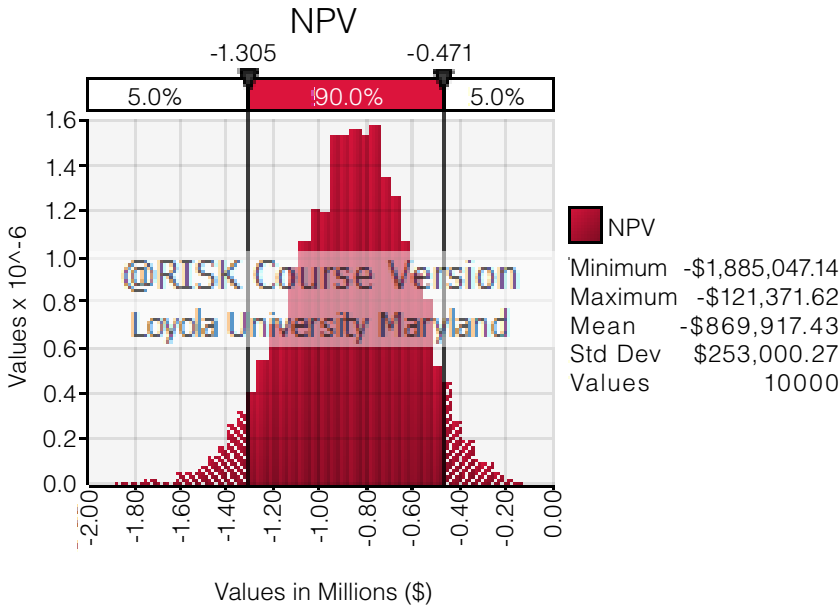
Table 4: Monte Carlo simulation assumptions for CBIBS project.

The variables are as follows:

- *Budget appropriations* represents government funding allocated for NOAA and consequently to CBIBS every year
- *Costs* represents the projected annual operating expenses for CBIBS
- *Buoy procurement* is the line item for the cost of replacement buoys and replacement buoy parts
- *R&D* represents research and development costs associated with ongoing work in search of new ways to enhance the effectiveness of the buoy program
- *Extended operations* is the line item for projected overtime costs
- *New products* represents the cost associated with procuring new technologies to enhance the value added by the buoy program

The simulation used 10,000 iterations to produce a distribution of projected cash flow for years 2016 through to 2020. The results are reported in Figure 6.

Simulation Summary Information	
Workbook Name	160907 CBIBs Monte Carlo data.xlsx
Number of Simulations	1
Number of Iterations	10000
Number of Inputs	12
Number of Outputs	1
Sample Type	Latin Hypercube
Simulation Start Time	9/7/2016 17:29
Simulation Duration	0:00:05
Random # Generator	Mersenne Twister
Random Seed	127563525



Summary Statistics for NPV			
Statistics		Percentile	
Min	($1,885,047.14)	5%	($1,304,761.15)
Max	($121,371.62)	10%	($1,207,151.67)
Mean	($869,917.43)	15%	($1,136,259.22)
Std Dev	$253,000.27	20%	($1,084,178.91)
Var	64009139143	25%	($1,037,992.17)
Skew	-0.219	30%	($995,729.74)
Kurtosis	2.897	35%	($956,675.10)
Median	($858,026.36)	40%	($924,500.84)
Mode	($784,096.28)	45%	($890,222.31)
Left X	($1,304,761.15)	50%	($858,026.36)
Left P	5%	55%	($826,632.11)
Right X	($471,050.14)	60%	($792,572.10)
Right P	95%	65%	($763,378.93)
Diff X	$833,711.01	70%	($730,094.76)
Diff P	90%	75%	($691,877.19)
#Errors	0	80%	($652,454.13)
Filter Min	Off	85%	($605,992.93)
Filter Max	Off	90%	($549,966.46)
#Filter	0	95%	($471,050.14)

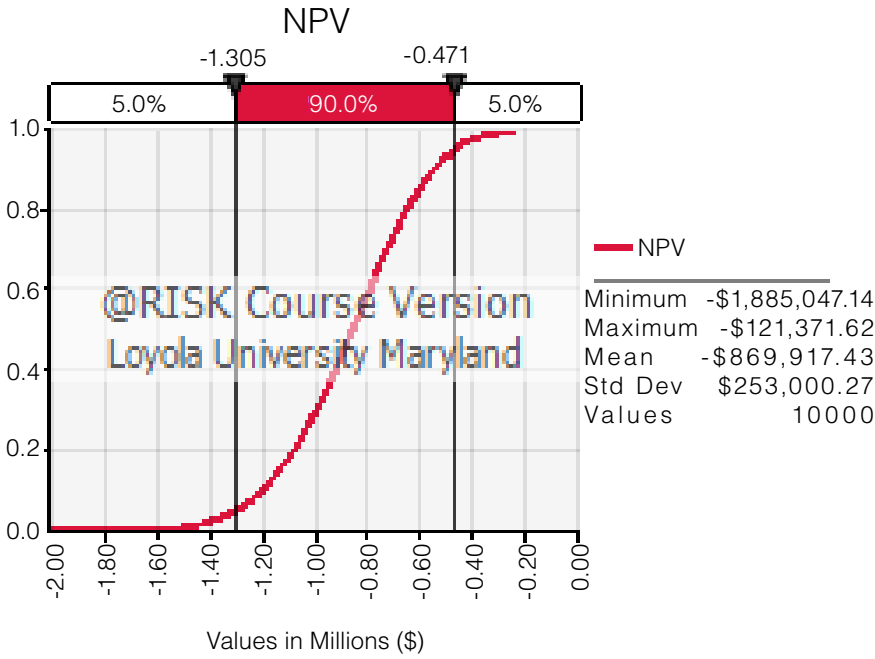


Figure 6: Simulation results using @RISK Course Version with a spreadsheet NPV model.

The average cost of running CBIBS is $869,917.43 every year with a standard deviation of $253,000.27. This compares favorably with an estimated created value of $4.6 billion which in turn generates a positive NPV of $3.7 billion. The simulation provides objective data on the value of CBIBS—the project is a benefit to multiple agencies, universities, and organizations.

Sensitivity analysis can help determine which variables have the greatest potential impact for CBIBS and therefore have the greatest chances of influencing project value. This Tornado diagram (see Figure 7) compares the relative importance of the variables—the *Y-axis* contains each type of uncertainty at base values and the *X-axis* contains the spread or correlation of the uncertainty to the studied output. Each uncertainty contains a horizontal bar and is ordered vertically from most to least impactful to show uncertainties with decreasing spread from the base values. The top five variables most critical to CBIBS are, not surprisingly, the budget appropriations for each of the five years under study. Cuts in these budgets create the largest impact on the value CBIBs is able to create for its constituents.

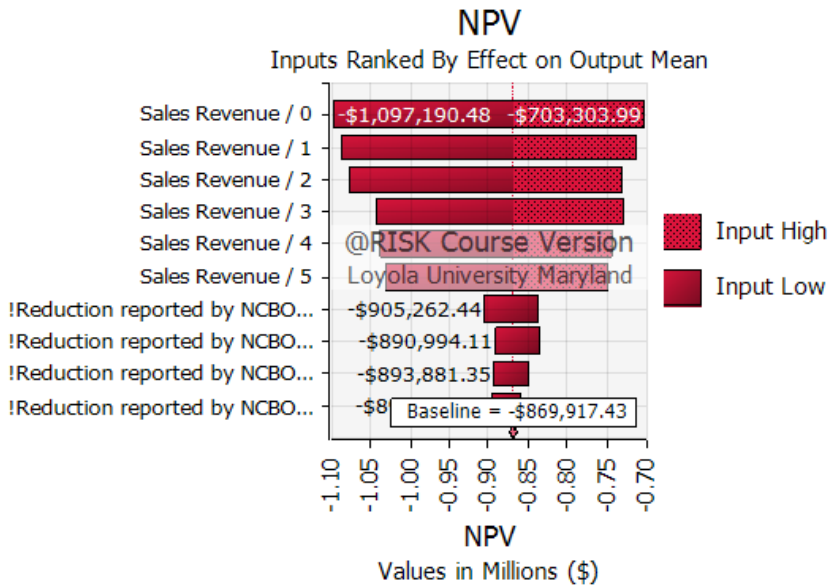


Figure 7. Tornado diagram for CBIBS. Each variable was independently considered for estimated net present value.

CONTRIBUTIONS OF THIS STUDY

This student project suggests a methodology integrated with operations and management that can track CBIBS costs in a way not previously done by the agency. Using accurate and consistent cost information, the Monte Carlo simulation can be applied to help make informed investment decisions and especially to prepare better for the costs of unscheduled maintenance. This is particularly important since the budget is a congressional appropriation—the Congressional Budget Committee appreciates transparency in models such as the Monte Carlo simulation and can see its sophistication in modeling variables with realistic distributions. Finally, this work also provides tangible insights into the value of CBIBS for stimulating local economies.

The National Oceanic and Atmospheric Administration eventually deemed this student experiential learning project to be substantial and sophisticated enough to assist it in justifying its budget request. The study was thus submitted to Congress to help rationalize the allocations requested by the Chesapeake Bay Office of the NOAA. Monte Carlo simulation was also deemed to be a modeling approach that could be applied by NOAA managers for budget justifications in the future.

Working with live data in the classroom, moreover, helps students to see the challenges of actually gathering the data and developing a financial model for data analysis. It also enhances student learning and improves retention and recall of theory when presented with the opportunity to apply such in the future. Finally, the outcome of the study can be used to introduce new modeling techniques to agencies and then have those techniques be adopted eventually by them.

There is immediate value creation for the student and potentially for the organization when experiential learning is accomplished through projects that benefit particular organizations (an environmental one in this case). Students will typically have a better understanding of the challenges associated with completing a comprehensive analysis. They have the opportunity to contextualize it, and they report more success in transferring classroom learning to their work world. Employers gain workers who are exposed to new theories and technologies and therefore are more productive and require less management. Students with advanced skills thus increase their earning potential by developing and refining their capabilities.

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FROM CRISIS TO SPECIALTY COFFEE
The Case of Nicaraguan Smallholder Cooperatives and Jesuit Business Education for Sustainability and Justice

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ABSTRACT

Project-based service-learning has been proven to be an effective experiential learning opportunity that complements standard curricula in business schools. Seattle University (SU) has collaborated with its sister university, Universidad de Centro Americana (UCA) in Managua, Nicaragua, since 2015 on several project-based service-learning experiences focused on sustainable coffee farming practices and the implications that climate change may have on coffee farms and communities. This partnership with UCA and coffee cooperatives has its roots in the global coffee crisis of the early 2000s and has produced multiple projects that support farmers entering the specialty coffee markets. This paper as such presents the outcomes of our annual field research that took place in Penãs Blancas, Nicaragua in March 2018. Using the framework of sustainable coffee in light of environmental, social, and economic sustainability objectives, we provide evidence that many farmers in Nicaragua have been experiencing issues with their farms' sustainability. Our findings, moreover, reveal that the direct trade model used by the SU student-run social enterprise Café Ambiental is the most effective means of ensuring the farmers' economic sustainability, thereby allowing them to develop the environmental sustainability of their farms as well as improve their family and community health, education, and overall livelihoods for enhanced social sustainability. This social enterprise model created by SU students takes significant steps toward fulfilling the needs and improving the lives of coffee farmers in Nicaragua while preserving the land at the same time so future generations can grow quality coffee. Finally, we believe that our project has potential that is transferable to other Jesuit higher education institutions that utilize and pursue similar structures and objectives.

KEYWORDS

sustainable coffee; cooperatives; Jesuit business education; Seattle University; Universidad de Centro Americana; Nicaragua

INTRODUCTION

Jesuit business schools have identified service-learning as one of the five pillars of Jesuit education along with ethics and professional responsibility, personal identity, social justice, and faith and spirituality (Spitzer, 2010). Indeed, project-based service-learning has been proven to be an effective experiential learning tool that complements standard curricula in business schools. It is possible, therefore, for Jesuit universities with a common mission and a long history of true partnership to work together for the promotion of social justice through service-learning projects, especially given the large network of Jesuit higher education institutions across the globe. The scope of these experiential opportunities, however, is often restricted to local projects due to limited access to resources that are essential for international efforts. This paper thus aims to document the outcomes of a project-based service-learning trip which could serve as a model of experiential learning for students at Jesuit higher education institutions around the world. The project, a recent international collaboration between Seattle University (SU) in the United States and its sister university, Universidad de Centro Americana in Nicaragua (UCA), demonstrates the commitment of Jesuit universities to develop leaders for a just and humane world, particularly through service for those on the margins while enriching opportunities for the education of the whole person.

Since the global coffee crisis of 2001–2003, faculty and students at SU and UCA have been collaborating to apply their expertise in service of the Jesuit mission. Multiple initiatives have been developed over the years, such as a chemistry-based project that developed a basic science of coffee fermentation kit to assist farmers in determining the optimal fermentation of their farms, an engineering project that developed coffee wastewater treatment facilities for small farms, and a couple of economic studies on fair trade, global coffee supply chain management, and sustainable coffee (Le, Wild, & Jackels, 2017).

In his encyclical *Laudato Si',* Pope Francis expressed his concern that

> climate change is a global problem with grave implications: environmental, social, economic, political and for the distribution of goods … many of the poor live in areas particularly affected by phenomena related to warming, and their means of subsistence are largely dependent on natural reserves and ecosystemic services such as agriculture, fishing and forestry. (Francis, 2015: #25)

The Pope strongly emphasized a need for collaborations to protect the environment among all groups. In response therefore to the encyclical, our annual project-based service-learning trip in 2018, organized by SU and UCA, focused on sustainable coffee farming practices in Nicaragua and on the challenges climate change presents to those practices. The primary objective of this project was to foster a partnership with colleagues at UCA and with cooperatives to assess the needs of Nicaraguan coffee farmer communities while also providing educational opportunities for students at SU and UCA through an experiential learning project.

The framework of sustainable coffee has three main objectives: environmental sustainability, which represents the eco-environment; social sustainability, referring to when the production system maintains respect for social principles; and economic sustainability, which pertains to the financial viability of the activity. Sustainable coffee farming practices in this context preserve the capacity of future generations of farmers to continue producing high quality coffee. Thus, accompanied by five faculty members and students from UCA, seven faculty members and students from SU (including the authors of this paper) traveled to Penãs Blancas, the coffee producing region of Nicaragua, for ten days in March 2018. Their research focused on analyzing the current sustainability of coffee farms and the issues farmers have been facing under the threat of climate change.

CAFÉ AMBIENTAL: A STUDENT-LED SOCIAL ENTERPRISE AND BUSINESS EDUCATION OPPORTUNITY AT SEATTLE UNIVERSITY

A group of business faculty and students from SU traveled to Nicaragua in 2015 with chemistry professor Susan Jackels and students and faculty from the engineering school to build a coffee wastewater treatment facility for a small cooperative farmer. While on the trip, the business team conducted an economic analysis of fair trade coffee. Their farm visits, surveys, and literature reviews revealed

that coffee farmers were receiving the least of the profits despite being the backbone of the coffee industry (Le et al., 2017). At the end of the trip, a first batch of coffee was purchased directly from the farmers who belonged to a cooperative that had assisted in the study (using a small amount of money that was left over from the grant of the Office of Global Engagement).

That purchase was the first step for what would later become the social enterprise Café Ambiental, SPC, which was established after the field research in Nicaragua exposed drastic inequities across the coffee value chain. The mission was simple: empower coffee farmers by providing fair and sustainable wages for the coffee they produce. The vertically integrated supply chain cut out the middlemen and guaranteed the largest percentage of profit possible for the farmers. Collaboration with students and faculty from UCA for remaining in contact with and supporting the farmers and their cooperatives ensured that operations were running efficiently.

Café Ambiental has been working directly with farmers in Nicaragua since 2015. Business students and faculty at SU have already gone on three annual field trips so far to Nicaragua to study the country's coffee industry and purchased four micro-lots to date of specialty grade coffee beans directly from the farmers. The business model centers on the economic empowerment of the farmers as it provides them with 65% of revenues. To date, over $30,000 in annual revenues have been generated from business to business and business to consumer sales on campus and in the greater Seattle community under the brand MotMot Coffee, named after the national bird of Nicaragua. The project has also provided support in various ways: in the academic year (AY) 2015–2016, proceeds from the business were used to purchase school supplies to support the education of farmers' children; in AY 2016–2017, the organization addressed transportation issues and funded bus transit to ensure that students were able to attend school, thereby improving attendance rates; finally, in AY 2017–2018, the organization supported, in solidarity with UCA, those students and their families who were impacted by the political turmoil in Nicaragua.

Café Ambiental was a key component in SU becoming the first Fairtrade University in the Pacific Northwest. It continues its operations today in the Albers School of Business and Economics as a student-created and student-run coffee business, selling fair trade organic coffee in the Seattle area and sending profits back to the farmers. The Café has grown yearly, starting out with a few students all the

way to today's 20-student team—comprised of six paid executives under a work-study program and fourteen unpaid interns—plus several others from a variety of disciplines on campus. It plans to remain within SU as a real-world incubator of business education where students can develop professional skills for the business world through experiential and project-based service-learning.

The project has been highlighted in several Seattle media outlets such as the *Seattle Times* and *Global Washington* as well as at SU's annual Scholarship Gala. It was also documented as a case study which received the Albers Faculty-Student Research Collaboration Award in 2018 and was published in *World Development Perspectives*. Faculty and students presented the project at the Nobel Peace Prize Forum's Workshop on Cooperative Movements in Central and Latin America in 2017 and at the Fair Trade National Conference in 2018. It placed second out of 45 teams at SU's Harriet Stephenson Business Plan Competition, was selected as a quarterfinalist in Seattle's Social Venture Partners Competition in 2017, and competed in the Global Social Innovation Challenge in 2018.

In 2019, Café Ambiental acquired 501(c)4 status as a non-profit organization in Washington State. It continues to grow its sales throughout the Seattle area and is seeking to expand to other university campuses as well. Such an expansion will strengthen not only the project's ability to impact coffee farmers positively but also the way it conveys its message of seeking sustainably and ethically sourced products in daily life to consumers, especially through the coffee bag's farmer-focused design. Indeed, the project received the AsiaNetwork Freeman Student-Faculty Fellowship in 2018 to conduct field research in Vietnam. Six students and two faculty members thus travelled to Vietnam in the summer of 2018 to study the coffee industry there, and the project began establishing partnerships with farmers utilizing the successful collaborations with Nicaragua as a model.

To evaluate the impact of Jesuit education through service-learning projects, reflections were conducted after the trip to Nicaragua. Students led conversations and shared their thoughts with fellow students, and their comments on the project were considered as metrics for the assessment.

> The trip to Nicaragua aligns well with the overall Jesuit mission … by exposing and encouraging students to interact with the system that is broken in our world and have a tangible impact on them.

> I think this trip exemplifies the Jesuit mission. Returning from this trip, I feel especially empowered to succeed in business while benefitting my community and other communities. There was an element of education for all parties involved in this trip, including the SU and UCA faculty and students and the farmers, which, in my opinion, is all a Jesuit program can hope for.

The Jesuit ideal of *cura personalis*—care for the whole person—along with holistic personal and professional student development are woven into Café Ambiental. As a Jesuit university with a strong commitment to social justice, SU expects its students to serve communities both at home and abroad whenever there is an opportunity. Thus, while the background knowledge and skills of the students involved in the project vary widely from business and economics to environmental studies and engineering, they all share a common goal: to contribute their skills toward the promotion of social justice. Café Ambiental involves students directly in the acquisition and distribution of coffee, thereby spreading awareness of equitable value chains among the greater population on campus. The project also increases student's sensitivity to current global issues, particularly with regard to inequities in Nicaraguan coffee production and the challenges of climate change.

This student-created coffee project is thus a unique, trifold educational experience for SU and UCA students, a critical partnership of two Jesuit universities under the Central America Initiative, and a powerful example of mission engagement in the Albers School. The educational focus extends beyond the basics and encompasses experiential learning for all parties involved, one that empowers business leaders to carry out the Jesuit mission of social justice. Moreover, this model of a successful social enterprise with international collaborations has the potential to be duplicated and transferred to other Jesuit higher education institutions that have similar structures and objectives.

THE NICARAGUAN COFFEE INDUSTRY

The coffee industry in Nicaragua employs about 332,000 persons or equivalent to 15% of the country's labor force and 54% of its agricultural sector (Bolaños, 2015). This cash crop industry contributes 14.3% of the country's agricultural GDP[1] despite having the lowest average yields in Central America at about 11 bags (or 660 kg) per

[1]From the Ministerio de Agricultura y Forestal (MAG-FOR). Data obtained in 2006.

hectare. About 97% of the coffee producers operate on small-scale farms and are concentrated mainly in Jinotega and Matagalpa with a total cultivated area of about 126,000 hectares (Bolaños, 2015). According to Läderach et al. (2011), however, the areas suitable for coffee production in this region will decrease by 16% by 2050, indicating substantial losses in the total cultivated area due to climate change.

The industry was analyzed using data on coffee trade statistics from the International Coffee Organization (ICO, 2015) coupled with supporting evidence from our recent field research in Penãs Blancas. The following indicators for analysis were taken from the ICO: total production by all exporting countries, domestic consumption, exportable production by all exporting countries, prices paid to growers in exporting countries, and retail prices of roasted coffee in selected importing countries. The data revealed that coffee prices have fallen severely since the early 1990s and hit their lowest dollar per pound (lb.) purchase price during the global coffee crisis from 2001 to 2003. The average real price of coffee in 1990 (ICO, 2015; base year = 2010), for instance, was $1.19/lb. before dropping to $0.59/lb. in 2001 and then bouncing back to above $1.00/lb. in 2006. According to the ICO, a pound of coffee in 2015 was $1.15.

In Nicaragua, coffee growers were receiving $0.44/lb. of coffee in 1990. During the crisis in 2002, however, the price of a pound of coffee dropped to as low as $0.30/lb. The fall in coffee prices during this time, according to the World Bank, led to a 10% increase in poverty in the coffee producing regions of Nicaragua. Only after the crisis did prices begin to stabilize and start to rise, reaching a peak of $0.91/lb. in 2011. Coffee farmers in Nicaragua today receive $0.72/lb.

According to ICO's historical data from 1990–2017, Nicaragua ranked 15th in the world in terms of coffee production, producing an average of 1,427 thousand 60kg bags annually with an average annual growth rate of 9.26%. The average price during the same period was $0.55/lb. According to Gay et al. (2006: 265), "production level does not seem to respond, or it responds very slowly, to changes in prices." Coffee supply price is thus rather inelastic. Nevertheless, Figure 1 provides a scatter diagram showing a positive relationship between prices paid to coffee growers and total coffee production in Nicaragua.

Figure 2 reveals a positive trend in production, exports, and domestic consumption. Nicaragua exports almost all of its coffee—total coffee production

and export rates grew at an annual rate of 9.26% and 9.47%, respectively, between 1991–2017 (ICO, 2015). The top five destinations for Nicaraguan coffee exports from 2013–2014 were the United States, Germany, Venezuela, Belgium, and Canada.[2] Domestic consumption in Nicaragua, on the other hand, is not as strong compared to other countries in the region due to a weak cultural preference for drinking coffee—Nicaraguans will only consume, on average, close to 2kg of coffee per capita annually. Moreover, according to the USDA Foreign Agricultural Service (Bolaños, 2015: 3), "Nicaraguan consumers do not purchase the more expensive types of coffee. Most of the coffee consumed in Nicaragua is not suitable for export."

Figure 3, on the other hand, reveals that consumers in the United States pay very high retail prices for roasted coffee while farmers in Nicaragua receive very little compensation for what they harvest. Growers in Nicaragua receive $0.55/lb. of coffee on average while consumers in the United States pay $3.67/lb., making for a difference of $3.12/lb. Where does the money go, then, if farmers are not receiving even the price for conventional coffee (a pound of washed, conventional Arabica coffee is around $1.40/lb. on average[3])? The traditional trading models in the coffee industry, as it turns out, utilize eight intermediaries between the coffee grower and consumer (Miller, 2009). In terms of value chain revenue breakdown, growers receive 10%, exporters 10%, shippers and roasters 55%, and retailers 25% (Ransom, 2006: 20).

[2]Information taken from the Centro de Trámites de las Exportaciones website at https://cetrex.gob.ni/.

[3]Taken from the ICO website.

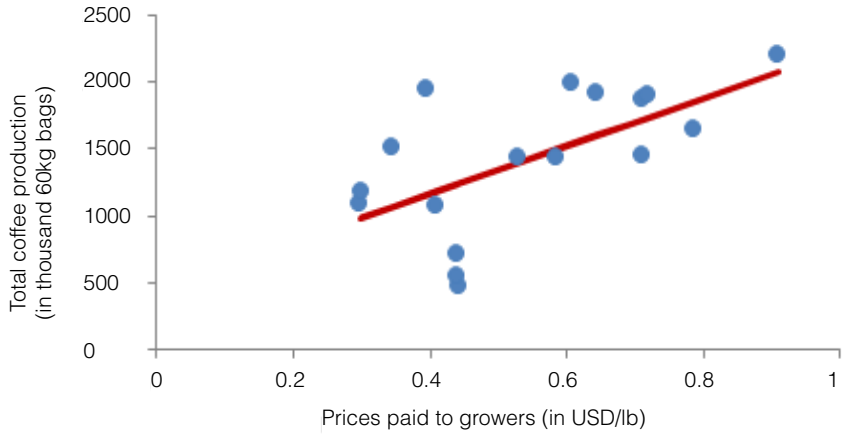

Figure 1: Prices paid to growers and total coffee production. Source: ICO (2015).

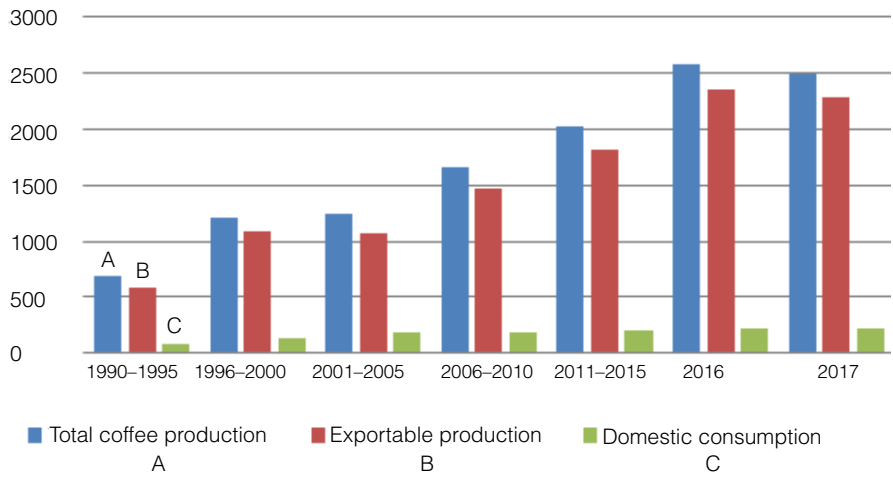

Figure 2: Total coffee production, exports, and domestic consumption.
Source: ICO (2018). Unit: thousand 60kg bags.

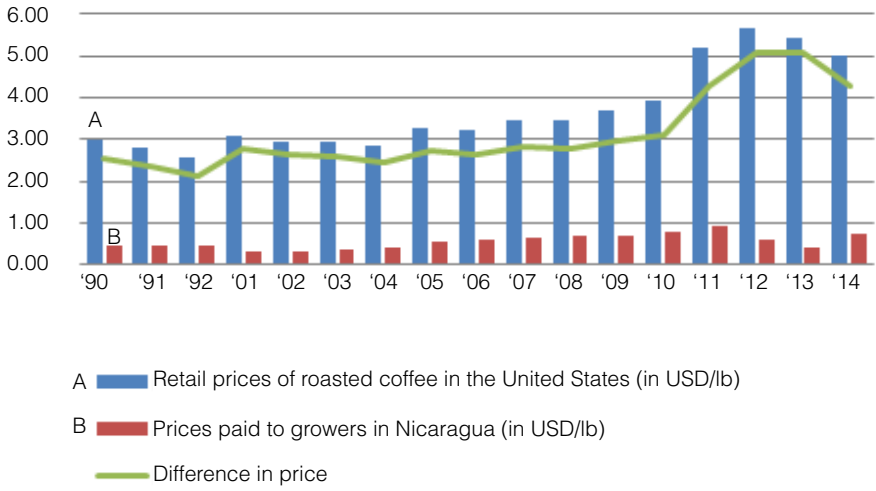

Figure 3: Coffee prices in the U.S. and Nicaragua. Source: ICO (2015).

The farmers we interviewed know clearly how inequitable the coffee supply chain is. They are aware that they are being exploited by middlemen who export their coffee. Several of them emphasized their inability to demand higher prices since the buyers would merely move on to the next farm or cooperative. As for the many farmers who expressed their desire to cut the middlemen out and work with more direct buyers, they lamented their lack of connections for establishing a direct trade partnership.

Several of the small farm owners we interviewed in Penãs Blancas also talked about the history of coffee prices and yearly fluctuations they have had to face. It began after the Nicaraguan Revolution in the 1980s which left the majority of coffee farms completely burnt. The commodity price of coffee began to decline as the farms were being rebuilt in the early 1990s, leading farmers to lose profits and making reinvestment in the farms a must. The majority of farmers were left with little personal spending money as a result. Then, when the profits were eventually not enough to support both the farms and the families running them, farmers began seeking external funding from local commercial banks, many of whom began offering small loans to farmers but at extremely high interest rates. When farmers were unable to repay the interest on the loan, the banks repossessed their land—a common scenario throughout farming communities in Nicaragua. Many farmers thus began working together and forming cooperatives to prevent financial collapse

and repossession. These cooperatives, which comprise the majority of small farmers in Nicaragua today, give them access to exporters as well as to loans they would otherwise be too small to qualify for.

The cooperative model has noticeably improved access to capital and foreign markets for many small farmers, thereby supporting their entrance into specialty coffee markets. The price fluctuations of coffee, however, still greatly impact those who are part of cooperatives—the farmers we spoke with experienced a price drop of about 20% in 2018 alone—a significant loss—and expressed concern about the potential for another coffee crisis like the one in 2002. Their best guess for this year's price is $127/quintal (1 quintal = 100lbs or 46kg) for specialty grade coffee which, to qualify as such, must receive a cupping score of around 84–87 points based on a 0–100 scale—a difficult score to achieve (SCA, n.d.). When we asked the farmers directly how much they would like to sell their coffee for, they modestly and fairly suggested $200/quintal. This is equivalent to about $2.00 per pound of coffee and just enough to keep them above the poverty line.

Since it buys directly from farmers by paying in advance those prices necessary for a sustainable wage, Café Ambiental's business model goes against the conventional practices of the coffee industry to address coffee farmers' economic and social sustainability issues. The company, which currently sources the high-quality, honey-washed Caturra variety of coffee from Gold Mountain Coffee's Matagalpa Community in Nicaragua, also purchases from across the cooperative rather than from only one or two farmers that produce exceptional coffee to prevent tension among member farms. For every 12oz. bag sold for $12.95 in Seattle, moreover, Café Ambiental returns $1.60 directly to the farmers as a premium on top of the advanced payments while $3.50 goes to a scholarship fund that supports their children (Le et al., 2017). This direct trade model thus provides farmers with peace of mind in knowing that they *will* receive a livable wage for the coffee they produce and mitigate their susceptibility to price fluctuations in the commodity market.

THE FAIR TRADE AND COFFEE COOPERATIVE MOVEMENTS IN NICARAGUA

As an alternative to the conventional trade model, the fair trade movement can be traced back to the late 1980s. It is based on a partnership between producers

and traders, with a single third-party intermediary setting a price floor for buyers and ensuring that farming practices are ethically and environmentally sound (Kilpatrick, Aguirre, Forkutsa, & Kaiser, 2015). A product certified as fair trade means that its producers and traders have met Fairtrade Standards which are designed to address the power imbalance in trading relationships, combat unstable markets, and eliminate the injustices of the conventional trade model (Kilpatrick et al., 2015).

According to Fairtrade International, whose member organizations represent the largest and most recognized fair trade system in the world, there were 445 coffee producer organizations from 2013–2014 that represented 812,500 small-scale coffee farmers across 30 countries, with 80% of all the fair trade coffee from those producer organizations coming from Latin America and the Caribbean (Kilpatrick et al., 2015: 73). More than 1.1 million hectares of land have been cultivated by fair trade coffee farmers worldwide, producing more than 549,000 metric tons of certified coffee per year (of which 34% was also certified as organic) (Kilpatrick et al., 2015). Fair trade coffee farmers in Latin America and the Caribbean, in particular, have cultivated on plots averaging 3.1 hectares each.

The prices applied to green bean purchases worldwide (SPO)[4] are $1.35/lb. for conventional natural Arabica coffee and $1.40/lb. for the conventional washed variety. Fair trade guarantees these minimum prices and adds a $0.20 fair trade premium (of which at least $0.05 is for productivity and/or quality) plus $0.30 for an organic differential. When the conventional prices rise above the fair trade minimum, fair trade buyers will match the market price and still pay the premium to the farmers (Kilpatrick et al., 2015).

The history of the fair trade cooperative movement in Nicaragua, on the other hand, dates back to when the coffee industry was essentially destroyed in the global coffee crisis of the early 2000s. Many farmers had to abandon their farms as the international price of coffee beans collapsed. In response to this, Catholic Relief Services (CRS) in Nicaragua distributed food to coffee farmers and their families to alleviate as soon as possible the burden of the crisis and its repercussions. This emergency relief effort eventually evolved into an ongoing CRS development project that focuses on helping Nicaraguan farmers rebuild their farms and communities in the wake of the crisis.

[4]Spot price data taken from the ICO website.

CRS then collaborated with both the Association for Local Agricultural Diversification and Development and Caritas Matagalpa to help farmers organize into cooperatives, provide technical training to help them improve the quality of the coffee they produce, issue guidance and support for farmers in their efforts to get their coffee certified as fair trade and organic, and connect the cooperatives to fair trade importers such as Cooperative Coffees (Miller, 2009). This new business model thereby supports the coffee farmers by helping them to improve the quality of their coffee, get their coffee certified, and reduce the number of intermediaries in the coffee value chain through direct trade.

There are now 33 producer organizations with fair trade certification in Nicaragua today (Kilpatrick et al., 2015: 159). The country once ranked fourth among the top ten in the world in terms of fair trade production capacity, with Nicaraguan farms producing 32,000 metric tons of fair trade coffee from 2013–2014 (Kilpatrick et al., 2015: 79) or about 27.5% of the total produced worldwide. Nicaragua also ranked fourth among Latin American and Caribbean countries in terms of fair trade employment with 28,200 fair trade farmers and workers or 9% of the total in the region (Kilpatrick et al., 2015: 157) and seventh among those in the region receiving fair trade premiums from 2013–2014 with €3.28 million (Kilpatrick et al., 2015: 158) or 5% of the total, equivalent to $4.38 million based on 2014 exchange rates. Each fair trade farmer or worker, in other words, received an average of about $155.17 in premiums annually. This is a relatively small amount for helping improve the productivity, quality of coffee, and livelihoods of farmers.

Raynolds et al. (2007) argue that certifications seeking to improve ecological and social expectations are likely to be challenged increasingly by those who seek simply to uphold current standards. Certifications also have their own issues, including the extent to which coffee farmers in Nicaragua are able to benefit from being certified and having to decide which certifications to obtain. Indeed, while most of the cooperatives in Nicaragua have limited themselves until now to Fair Trade and organic certifications, the rise of new competing certification organizations such as Rainforest Alliance, Starbucks C.A.F.E. Practices, Bird-Friendly Coffee, and UTZ Certified is setting up new challenges for farmers who lack knowledge about each scheme (Valkila & Nygren, 2009). Bacon (2005), for instance, claims that Fair Trade certified and organic are two alternative forms of specialty coffee trade and production that may offer opportunities for small-scale farmers. He argues

that participation in organic and fair trade networks reduces the vulnerability of their livelihoods.

To understand the benefits and challenges of being certified by these sustainable certification schemes, we studied three unions of cooperatives in Penãs Blancas during our visit to Nicaragua. One of those we met with was the Cooperativa Agropecaria de Producción Guardianes del Bosque R.L. which was founded in 2003 to help farmers recover from the coffee crisis. This union is composed of six cooperatives that hope to sell coffee to specialty markets by working together and has since expanded to 68 members, 27 of whom are women.[5] The members of the cooperatives immediately emphasized the need for sustainable cultivation of the land and for protecting hundreds of hectares of natural forests while simultaneously diversifying crops on the farms to ensure the health of the soil. Many farmers as such began to obtain certifications to market their coffee as truly sustainable.

While each of these certifications have had varied effects, several of the farmers agreed that these have been beneficial for their farms and extrapolated their main benefits to be technical support in and knowledge of best farming practices for developing their farms as well as knowledge of general operations management such as accounting and inventory tracking. They also noted, however, that these benefits have come from harder work and higher operational costs which have simply become the new norm throughout the region. Such certifications were originally intended to be alternative diversifying factors that would allow farms to stand out as high quality and result in higher prices for their beans. It has become instead a normal standard that all farmers must have to sell their beans to any international buyers. Indeed, several farmers viewed Fairtrade Labelling Organizations International (FLOCert) as the only economically beneficial certification.

Yet while FLOCert sets a floor price, a minimum amount the coffee should sell at, even this floor has fallen through for many of the farmers we spoke with. One of the main leaders of the union even became emotionally charged as he explained their relationship with buyers. He noted that they often reach out and agree to buy a set amount of coffee but change the conditions when the actual contracting and purchasing begin. They then insist on purchasing only half of the beans at the fair

[5]The majority of the union's farmers obtained the Starbucks C.A.F.E. Practices certification in 2011. Most then became UTZ certified in 2012 and Rainforest Alliance certified in 2017. The cooperatives, 40% of which produce specialty grade coffee, are audited by all these organizations.

trade price and the other half at the conventional price which is about $0.60 less per pound. They have grown greedy and refuse to purchase all the beans at the fair trade price even though the whole lot is fair trade and often even organic. He softly lamented that he lacked the knowledge and power as a farmer to negotiate with the buyers. Indeed, selling half the beans at the fair trade price and the other half at the conventional price is a better offer than not selling the coffee at all.

Constituted in 2016 and having obtained its official jurisdiction in 2017, the Union de Cooperativas para el Desarrollo Economico y Social, R.L., or UCODES (Union of Cooperatives for Economic and Social Development) is a relatively new union that seems to fare better compared to the one we visited previously. It consists of 12 cooperatives located in 12 communities in the municipality of La Dalia, has 320 members (199 men and 121 women), and its main objectives are to produce coffee, cocoa, and basic grains; promote environmental protection; and implement and finance projects that benefit the cooperatives. The union, which produced 3,154 quintals of coffee (certified by Rainforest Alliance and Starbucks C.A.F.E Practices) during the 2017–2018 harvest season, has the long-term goal of obtaining FLOCert and converting their farms to completely organic practices. They are getting paid direct quotes of the New York Spot coffee commodity prices plus $15 per quintal which is different from many producers and a positive sign of price transparency.

UCODES, which has been marketing its own roasted coffee under the brand Las Brisas del Penãs Blancas since 2014, is currently looking into reducing the sale of raw coffee beans and selling roasted and branded coffee in the United States instead to add to the value chain. The union continues to support the production and promotion of coffee, cocoa, and basic grains under their own brands and receives financial support from La Fundación Felipe Rinaldi in Spain and from ODESAR (Organización para el Desarrollo Económico y Social para el Área Urbana y Rural [Organization for Economic and Social Development for the Urban and Rural Area]) in Nicaragua to fund these projects. CAIXA, a Federal Savings Bank in Brazil, also helped the cooperatives apply for credit, thereby supporting them in localizing processing and roasting for their native brand as part of their plans to open a bigger processing mill. Being able to process the coffee locally means they will depend less on the beneficio (dry mill) which is the Beneficaffora “OLAM” Grupo Fhelca Sociedad Anomina in Matagalpa, thereby decreasing their production costs.

Another cooperative, Cooperativa Agricola de Servicios Las Brisas del Penãs Blancas, R.L (Las Brisas), received organic certification issued by MayaCert (acceptable as a USDA Organic Certificate) in Guatemala in 2018. Las Brisas has 170 producers covering a total of 394 hectares, and its farmers produce 100% Arabica coffee of which 60% is organic and the other 40% conventional. The quality of their coffee according to one farmer is between 83–86 points. Indeed, UCODES seems to be more organized and successful despite being recently established compared to other cooperatives we have worked with in Nicaragua since 2015. There are limitations, however, to the amount of capital available to coffee farmers, thereby limiting production. Access to credit rather than their ability to sell their coffee, the leaders of the union claimed, was the biggest constraint for the development of their farms.

The certification systems that allow farmers to enter the specialty coffee markets are not perfect but they are a step in a positive direction toward achieving economic and social sustainability for many cooperatives. Ensuring that price floors are set and truly enforced is essential for limiting the corrupt practices of greedy buyers whenever they purchase coffee from farmers. Further establishing trade partnerships directly with buyers, where middlemen exporters are eliminated, is the key for farmers to receive the higher prices they deserve for their coffee. The direct trade model which Café Ambiental utilizes thus ensures that farmers always receive a livable wage despite any fluctuations in global coffee prices. By eliminating the extra costs paid to middlemen that traditional export trade models operate with, such close ties formed between farmers and consumers protect farmers from the financial instability brought on by price fluctuations in the commodity markets. Café Ambiental's model, in essence, ensures the economic stability of farmers by minimizing the steps between them and the consumer.

IMPACT OF CLIMATE CHANGE ON SUSTAINABLE COFFEE PRODUCTION IN NICARAGUA

We now shift our attention in this section to environmental sustainability. Using primary data from field research, secondary data from a previously conducted environmental analysis, and readings of bioclimatic indicators such as temperature and rainfall for the period 1990–2015 from the Climate Change Knowledge Portal[6], we analyze the impact of climate change on coffee production in Nicaragua.

[6]See https://climateknowledgeportal.worldbank.org/.

The average annual temperature in Nicaragua, 25.25°C, fluctuates minimally due to the country's equatorial location and reaches a low of 24.14°C and a high of 26.09°C. Research by Läderach et al. (2010 and 2011) predicts that 92% of the coffee producing regions in Nicaragua should expect a temperature increase of between 2.25–2.50°C by 2050. The rise in temperature in turn will have a severe impact on coffee production, thereby putting the livelihoods of farmers at risk. Bejan et al. (2018), for instance, estimated that a 1% rise in the average annual temperature will reduce the production of coffee by 8.75%. Utilizing this estimate, we show that if the average annual temperature in Nicaragua rises from 25.25°C to 25.50°C, total coffee production would be reduced from 1,427 on average to 1,302 thousand 60kg bags. This is equivalent to a decrease of more than 16.5 million pounds of coffee. With the average price at $0.55/lb, coffee growers in Nicaragua would thus lose about $9 million per year. Figure 4 reveals a negative relationship between changes in temperature and total coffee production in Nicaragua (1990–2015) and confirms the severe impact that rising temperature has on the production of coffee.

Climate variability may also threaten future coffee production in these regions due to competition for water. According to the International Water Management Institute, rainfed agriculture accounts for 90% of how crops in Latin America receive an adequate supply of water (IWMI, 2010). The average annual rainfall in Nicaragua over the period 1990–2015 is 195mm with 287mm in the wettest quarter and 103mm in the driest. Läderach et al. (2010 and 2011) predict that precipitation in the coffee growing regions of Nicaragua will decrease by 60mm and 7mm in the wettest and driest quarters, respectively, by 2050. Figure 5 shows a negative relationship between total coffee production and changes in rainfall in Nicaragua.

Läderach et al. (2010) have also studied the impact of climate change on pests and diseases in the coffee producing regions of Mesoamerica. They find that changes in temperatures and rainfall will increase pest and disease occurrence and expand the altitudinal range in which the fungal disease coffee rust and the coffee borer beetle can survive. Their study also reveals that higher temperatures speed up the ripening of coffee barriers which results in lower cup quality and lower prices. According to the authors, moreover, given that the first showers of the rainy season prompt coffee flowering, heavy and irregular precipitation patterns may cause both coffee flowers and cherries to fall off the tree, resulting in fewer cherries and lower quality beans (Läderach et al., 2010).

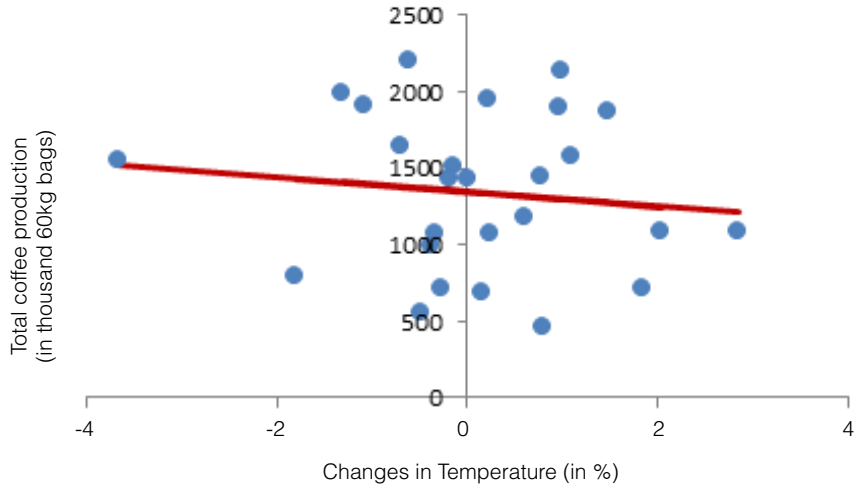

Figure 4: Total coffee production and changes in temperature. Source: ICO (2015).

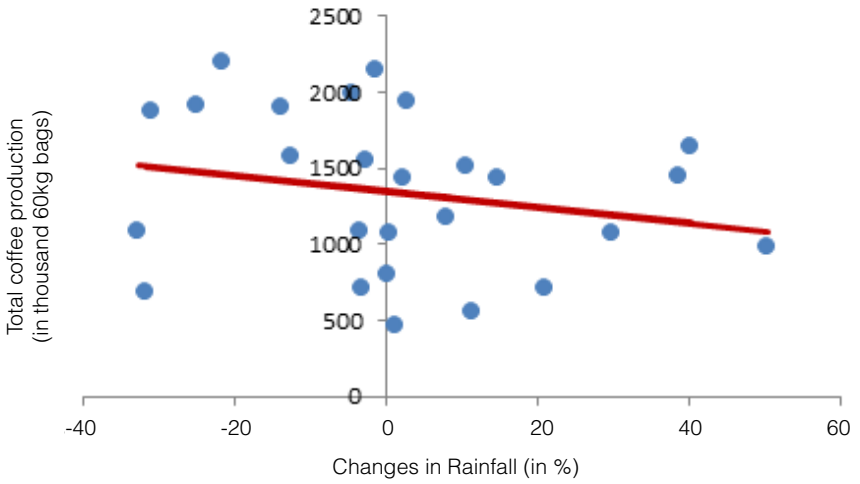

Figure 5: Total coffee production and changes in rainfall. Source: ICO (2015).

Unfortunately, such predicted changes in weather patterns have already become a reality for many of the farmers we spoke with during our field research. For Penãs Blancas, located at altitudes between 800 and 1,745 meters above sea level in the northern departments of Jinotega and Matagalpa, the rainy season extends from

May through February and precipitation per year above an altitude of 1,000 meters ranges between 1,200 and 2,500 millimeters. Median temperatures range between 20° and 24°C.

The head of the Cooperativa Agropecaria de Producción Guardianes del Bosque R.L., who has been a part of the union since its inception in 2003, commented that he has noticed increases in overall temperature across the seasons over the past several years, thereby causing the roya fungus to spread much faster and affect far more trees than ever before. As such, even though the chemicals he currently uses to help fend off the roya fungus have been approved by Fairtrade International and been quite successful, they add a significant cost to his farming practices. He has since begun experimenting with several homemade traps and pesticides in addition to the chemicals.

Another farmer in the union who we interviewed talked about the recent changes he has noticed in the flowering season of his crops. Historically, he had been planting and preparing his 25-hectare plot in anticipation of flowering to occur mostly in the month of May. This would allow the beans to develop until October when he would then expect the harvest season to begin and last through January. Within the past two years, however, the percentage of his farm that flowers in May dropped from 50% to its current state of 10%. Moreover, what used to be two main flowerings in May and June has now become a trend of seven flowerings stretching from February through May. This increased variance in flowering times that have now been spread over four months creates several new variables which farmers must learn to balance, including noting down when certain plants flower to find out when they will be ready for harvest and knowing when to begin replanting for the coming year. With plots of land spanning several kilometers, there is also a strain on cherry pickers to know when and where to begin harvesting the beans. Our findings are thus consistent with those of Läderach et al. (2010) who claim that erratic flowering and ripening cycles could require additional harvesting cycles and raise costs of production.

When asked what the biggest issue he faced recently was, the farmer quickly responded that heat and a lack of rain have greatly impacted his farm. He has begun planting other crops such as bananas for shade as well as beans and corn for supplemental income and experimenting with cacao and other shade trees to see if they can improve his soil quality. He has been using chemicals on all his land and

does not think he can stop anytime soon due to the losses he expects to face from bugs and the roya fungus. He also noted that the bugs, specifically the coffee borer beetles, have been increasing, yet he was hopeful that the recent changes he made to diversify the crops on his land would decrease the impact the bugs and fungus were having on the coffee. He and other farmers have also been experimenting with different varietals of coffee—Bourbon, Caturra, Catimor, and Robusta—to determine the best yields and resistance to climate stress.

We confirmed what this particular farmer was talking about regarding many of these changes in weather patterns when we visited several other farmers about 100 kilometers away who were leaders of the Union de Cooperativa de Café Especial Cordillera Isabelia R.L. Three of them who were concerned specifically about the environment discussed their experience with us. When asked about some of the challenges they were facing with their farms, two of the farmers immediately responded that it was the roya fungus. Impacting farmers around the world, this fungus has been known about for a long time and various studies have proven that increases in temperature paired with heavy rainfall patterns are favorable conditions for it to thrive. All three of the farmers then talked about their attempts to improve the quality of their soil by increasing the diversity of their crops. They use these other crops, such as bananas, beans, and pineapples, which have been growing throughout their farms to help subsidize coffee growing outside of harvest season.

Historically, the harvest season used to be always dry or have minimal rainfall which is ideal for the coffee and the conditions in which to harvest the beans. The season from October 2017 to January 2018, however, was especially challenging for all three farmers who dealt with intense rainfall throughout. This posed two big challenges. First, coffee is a rather needy crop; although it requires rain during the flowering and beginning stages of growth, too much rain during the harvest season can quickly damage the coffee fruit as it is completing its development. Heavy rains also cause the soils to become too unstable for the crop's proper growth. This is because pesticide use is directly linked to soil instability as it strips the land of vital nutrients and leads to higher rates of erosion, leading many farmers to strive for organic practices. Farms with unstable soils also make access to the coffee trees difficult, especially if the harvest season is plagued with heavy rainfall. Some of the higher elevation areas quickly become unreachable, and beans can no longer be harvested once they have been left on the plant for too long. This leads

to the second big challenge: while the farmers noted that they generally help one another during the harvest season, available labor was a rare find this past year, making the general support farmers provided one another during the harvest season unfortunately limited. This was because farmers throughout the region were scrambling to pick and collect as many beans as possible during the heavy rains before they overripened on the plants. Ultimately, such intense rainfall right at the peak of the harvest caused massive losses for all three cooperatives as well as for the union. When we asked the farmers to try and monetize how much coffee they lost, they could not put a number on it but they did note that they were unable to cover their operational costs for last year.

Our field research on environmental sustainability has thus aligned with previous studies that were done on a larger scale. The farmers we interviewed were innovative in adapting to climatic variability over the recent years by experimenting with climate stress-resistant coffee varieties, developing homemade traps and pesticides, and introducing shade trees onto their land. Given the importance of coffee to the Nicaraguan economy, however, adaptation strategies for coping with climate change should be made a priority at the national level to support the farmers. One of the most effective means of providing support, moreover, comes from encouraging and supporting direct trade partnerships like that of Café Ambiental, which provides farmers with the economic stability they need so they can invest in the sustainable development of their farms, families, and communities, thereby decreasing their susceptibility to climate fluctuations.

CONCLUDING REMARKS

The sustainable coffee framework designed in this project allowed us to gain knowledge about the coffee industry in Nicaragua, particularly from the crisis in the early 2000s to specialty markets in the present, and the current challenges under the threat of climate change which farmers face today. There is evidence projecting that climate change will reduce total coffee growing areas around the globe by as much as 50% by 2050 (Bunn, Läderach, Rivera, & Kirschke, 2015). This severe reduction will have a negative net impact on 25 million coffee farmers majority of whom are smallholders and on 125 million livelihoods in more than 70 countries that depend on coffee. Nicaragua depends heavily on coffee production for exports, with 17% of export earnings coming from this crop alone. Sustainable coffee is essential,

therefore, for enabling future generations of Nicaraguan coffee farmers to continue production while preserving the environment.

Indeed, this study shows that many farmers in Nicaragua are experiencing issues with their farms' sustainability and are thus in need of strong and direct trade partnerships that can provide them with the support and consistency necessary for improving their farms. While being part of a cooperative has been beneficial for many small farms as it creates a community of support and combines resources to help one another, it has also left many farmers vulnerable to exploitation by exporters who purchase from the cooperatives at unsustainable prices. With low levels of income, farmers are left to continue unsustainable farming practices and struggle to obtain the many certifications such as Fairtrade, Rainforest Alliance, and Starbucks's C.A.F.E Practices that have now become prevalent and almost essential to selling their beans. As such, despite the fact that these certification systems do help bring small farmers from the conventional to the specialty markets, they have become more of a necessity, a norm instead of an advantage, for selling beans in the region. Nevertheless, these certifications need to be honored by exporters who can be evaluated by audits from the certification organizations to ensure that farmers are not being exploited and receiving prices lower than the set price floor. SU's sustainability studies and direct work with farmers over the past four years, moreover, have ultimately revealed that the direct trade model used by Café Ambiental is the most effective means for ensuring farmers' financial stability. This in turn allows farmers to develop the environmental sustainability of their farms even further by transitioning to organic or regenerative farming practices or investing in other equipment. Thus, an environmentally healthy farm working with a partner that provides economic stability allows for the social sustainability of the farms to flourish along with finances for improving family and community health, education, and overall livelihoods.

This project-based service-learning opportunity also went beyond mere research and provided students at SU with unparalleled business and life experiences. Kolvenbach states that graduates of Jesuit universities should have a "well-educated solidarity" with the least in society, and that "solidarity is learned through 'contact' rather than through 'concept'. When the heart is touched by direct experience, the mind may be challenged to change" (Kolvenbach, 2000: 155). We thus find that project-based service-learning has been a learning experience that enhances

students' awareness of and sensitivity to current global issues. That awareness was established in this instance with regard to Nicaraguan coffee farmers and the coffee industry as a whole after the students worked directly within the industry. As a result, we believe that our students will approach career and professional development with a greater understanding of their impact on social justice. Our final thought is a comment from one of them:

> The trip to Nicaragua to work with coffee cooperatives is a perfect example of empowering others for a just and humane world while gaining valuable professional development. This trip defines in my opinion what all trips at Seattle University should do with a service-learning component. Through engaging in solidarity and collaborating with local farmers, we not only empower those we work with but we in turn are empowered.

SU has been collaborating with our sister university to support the farmers in Nicaragua and improve the quality of their coffee for entry into the specialty markets ever since the global coffee crisis began. As such, while we do not take any credit in their endeavor, the farmers do acknowledge that both our belief in their capability and our encouragement have made a difference for them. Nevertheless, there are still many needs that have to be addressed before coffee farmers can fully capitalize on the benefits of sustainable coffee production and the specialty markets. The social enterprise created by SU students demonstrates a model that fulfills some of those needs, thereby helping to improve the lives of coffee farmers while preserving the land so future generations can grow quality coffee.

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THE ROLE OF SYSTEM TRUST AND RISK PERCEPTION IN PROVIDING ASSETS FOR COLLABORATIVE CONSUMPTION SCHEMES

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ABSTRACT

The emergence of the sharing economy has fueled the development of collaborative consumption (CC) schemes around the world. The promise of non-ownership particularly in the peer-to-peer environment makes it attractive for a plethora of users to engage in practices such as carsharing and the rental of private holiday accommodations or tool supply from their peers. Yet while financial and environmental benefits for both users and providers do exist, providers of private goods may be reluctant in many cases to offer their belongings for sharing. This study thus draws on social exchange theory to examine the key role of generalized, barter- and money-balanced reciprocity as a pivotal scheme characteristic that predicts the intention of providers to participate in peer-to-peer CC schemes. As such, the findings from two empirical studies provide evidence that consumers are most eager to provide their personal assets against a reciprocal compensation where perceived risk functions as a mediator of the explained effect. Market mediation is also used to show that CC schemes are more attractive to consumers when facilitated by a non-profit market intermediary (vs. a for-profit intermediary), emphasizing the propensity of consumers to escape the market while sharing. A mechanism in which system trust mediates the proposed relationships is therefore suggested.

KEYWORDS

sharing economy; collaborative consumption; trust; reciprocity

INTRODUCTION

Also known as the "collaborative economy," the sharing economy refers to the temporary access to products or services with the collaboration of other consumers and/or intermediaries (Decrop, Del Chiappa, Mallargé, & Zidda, 2018). It is a new paradigm largely supported by peer-to-peer online platforms that bring together private providers and users of goods or services. Such an economy has developed rapidly in the last decade, supported by societal, economic, and technological factors (Botsman & Rogers, 2011). A report by PwC predicts that 5 key sharing sectors (P2P finance, online staffing, P2P accommodation, car sharing, and music/video streaming) have the potential to increase global revenues from $15 billion in 2014 to $335 billion by 2025 (PwC, 2015). In the United States alone, familiarity with sharing economy services has grown tremendously from 47% in 2015 to 83% in 2018, and the number of sharing economy users is likely to grow from 44.8 million users in 2016 to 86.5 million in 2021 (eMarketer, 2018). The promise of non-ownership has made it attractive for a plethora of consumers to engage in carsharing (e.g., Drivy) or the rental of private holiday accommodations (e.g., AirBnB) or tool supply (e.g., Neighbourgoods) from their peers (Hamari, Sjöklint, & Ukkonen, 2016; Zervas, Proserpio, & Byers, 2017). Champions such as Uber or AirBnB represent huge market capitalizations of almost $72 billion and $38 billion respectively (Forbes, 2018).

Research on the sharing economy has recently attracted interest from many disciplines including economics (e.g., Martin, 2016), information technology (e.g., Acquier, Daudigeos, & Pinkse, 2017; John, 2013), transportation (Cohen & Kietzmann, 2014), environmental sciences (Wu & Zhi, 2016), and tourism (e.g., Dredge & Gyimóthy, 2015). Authors have also begun to investigate the economic, environmental, and social impacts of sharing within different frameworks (e.g., Palgan, Zvolska, & Mont, 2017).

Is The Sharing Economy More Sustainable?

Early research outlets have praised the sharing economy for promoting a more sustainable way of living and running businesses through the favoring of access over ownership (Botsman & Rogers, 2011; Decrop et al., 2018; Heinrichs, 2013; Martin, 2016; Stokes, Clarence, Anderson, & Rinne, 2014; Wosskow, 2014). They present the sharing economy as a transformative force that enhances shared access and higher

levels of utilization of already produced but underutilized goods: "it often extends products' life span through second-hand markets, thereby theoretically reducing the need for production of new goods and thus for using virgin resources" (Palgan et al., 2017: 70). Nijland and van Meerkerk (2017), for example, find that a person using carsharing is likely to generate 30% less car ownership, 15–20% fewer car kilometers, and 13–18% lower CO_2 emissions compared to an individual who already owns a car. A number of other social benefits of the sharing economy have also been put into light, including cheaper access to services, altruistic non-reciprocal exchange, collaboration, trust, and social bonding among individuals (Bauwens, 2005; Belk, 2010; Benkler, 2017). Finally, the sharing economy is presented from an economic perspective as an opportunity for many to either earn or save money by escaping the tyranny of established marketplaces through decentralized peer-to-peer networks: "the sharing economy is seen as supporting strong emancipatory ideals for individuals and communities by promoting new types of organizations and exchange" (Acquier et al., 2017: 8–9).

More recent studies, however, have qualified the premise that the sharing economy is (more) sustainable per se compared to the conventional economy. A recent special issue of the *Environmental Innovation and Societal Transitions* journal that was devoted to sustainability perspectives on the sharing economy concluded, for instance, that

> the early claims of the inherent sustainability of the sharing economy are ill-founded. Not only are many providers and users primarily motivated by the economic gains to be made by trading on sharing platforms, the environmental effects may anyway well be rather limited due to increased demand triggered by lower prices as well as various rebound effects. (Frenken, 2017: 2)

Indeed, empirical research suggests that users' environmental motivations are often of secondary importance compared with economic reasons (Böcker & Meelen, 2017; Wilhelms, Henkel, & Falk, 2017). Sharing initiatives have been attacked for stimulating consumption and providing access to goods that people could not afford previously (Schor, Fitzmaurice, Carfagna, Attwood-Charles, & Poteat, 2016; Cohen, 2006), and companies such as Uber or Airbnb are often presented as framing a 2.0 capitalism that shapes unregulated marketplaces and unfair competition, facilitates tax avoidance, and recreates the inequalities of the capitalist markets by transferring risks to consumers (Martin, 2016; Schor et al., 2016). In conclusion, the sharing

economy shows many faces and an internally complex nature that aggregates a number of paradoxes around environmental, social, and economic promises.

RESEARCH PROBLEM

The emergence of the sharing economy has fueled the development of collaborative consumption schemes around the globe (Sacks, 2011). We define collaborative consumption as "people coordinating the acquisition and distribution of a resource for a fee or other compensation" (Belk, 2014: 1597) and where the resource being shared can be owned either by a business (business-to-consumer sharing) or a private consumer (consumer-to-consumer sharing) (Graul, 2017). Consumer-to-consumer exchanges are often facilitated by mediating online platforms that bring provider and user together. A triadic, platform-based environment in which consumers act as "micro-entrepreneurs" (Kumar, Lahiri, & Dogan, 2018) thus emerges, resulting in a multi-billion-dollar collaborative consumption industry (Sacks, 2011). Yet while prior research has begun to examine consumers' motivation to engage in collaborative consumption as a *user* or *renter* (e.g., Bardhi & Eckhardt, 2012; Decrop & Degroote, 2014; Möhlmann, 2015), research investigating drivers for consumers' participation in peer-to-peer short term rentals as a *provider* remains scarce. The latest sharing economy developments reveal, however, that there is a strong need to attract providers rather than users and have the former share their assets. Airbnb, for instance, can maintain its business operations only by securing sufficient consumer listings on its website; it counts over 200 million guest arrivals worldwide yet only 4 million listings are registered (AirBnB, 2017). The company aimed to address this imbalance by introducing a referral credit for which consumers are rewarded nearly twice the amount for a host (EUR 58) compared to a guest (EUR 31) referral (AirBnB, 2017). Attracting providing consumers to the sharing economy thus remains a managerial challenge. Consequently, the goal of the present research is to shed light into this opportunity and elucidate what role platform characteristics play in motivating consumers to provide their personal assets for sharing in collaborative consumption schemes—and which of these may hinder their motivation.

The paper will first review current consumer-to-consumer collaborative consumption schemes. Second, the authors will introduce a theoretically-driven classification of such schemes into three distinct reciprocity types (generalized,

barter-balanced, and money-balanced) and two forms of market intermediary (for-profit and non-profit). Third, the primary data of two experimental studies will be presented to investigate how reciprocity and market intermediary influence the intention to provide assets for sharing in collaborative consumption schemes through a process involving both system trust and risk. The findings of this research thus contribute to existing literature by showing that peer-to-peer sharing scheme characteristics such as types of reciprocity and market intermediary significantly impact upon consumers' intention to provide objects for sharing. Both a cognitive (risk perception) and an affective (system trust) route are proposed to account for the theorized impact. The paper will conclude with theoretical contributions and managerial implications that illustrate avenues for attracting private consumer sharing which may benefit public policymakers and managers of sharing platforms.

THEORETICAL FRAMEWORK

The Role of Reciprocity

Social exchange theory (Blau, 1964) is a useful framework for examining the role of reciprocity in consumer-to-consumer exchanges. Thus, while prior research suggests that sharing may involve reciprocal expectations from users (Belk, 2010), the authors assume that reciprocal anticipations may also play a crucial role for providers when sharing their assets. Indeed, the emerging literature on the sharing economy (Ikkala & Lampinen, 2015) indicates, first of all, that the possibility to earn money is an important factor for igniting participation in a sharing scheme and, secondly, that the presence of money plays a central role by providing the exchange with a structure and formality that contributes to the participant's sense of control and ease of participation. Scholars argue that social exchange occurs when both parties find themselves to rely on each other. They distinguish between two types of reciprocity (Sahlins, 1972), namely, 1) generalized reciprocity, in which the giver does not expect any direct return from the receiver, and 2) balanced reciprocity, in which an equal return is expected. Bardhi and Eckhardt (2012) argue that generalized reciprocity is close to Belk's concept of (genuine) sharing which does not include reciprocal expectations (monetary fees or the exchange of other assets) and is more likely to arise within structures with high levels of confidence such as families. Benkler (2017) refers to this as non-reciprocal pro-social behavior. Balanced reciprocity, in contrast, may be present in a plethora of

transactions between individuals due to the natural human tendency to expect a return when giving (Belk, 2010). This paper specifically introduces two types of balanced reciprocity: money-balanced (involving payment of a monetary fee as return) and barter-balanced (defined as access to another good within the scheme as return).

It may be reasonable to assume, then, that the presence of compensations significantly increases consumers' willingness to share their private goods for CC. Indeed, Gollnhofer and colleagues' recent paper on perceptions of fairness (2016) shows the omnipresence of the motto "If you want to get something, you also have to give" (228) based on empirical evidence gained from studying Napster users. Habibi, Kim, and Laroche (2016) most interestingly introduce a sharing score that is based on the same dialectic; it specifically weighs pure sharing versus pure exchange characteristics that range from Couchsurfing to Zipcar. They find with regard to the user perspective that cost and utility factors are to a great extent particularly able to explain the variance in participation likelihood for users. The present paper thus argues in addition that clear expectations of reciprocity exist for providers when it comes to participating in CC; more specifically, that:

H1: Consumers' intention to provide their private possessions for sharing is at the highest in money-balanced schemes followed by barter-balanced ones, and is at the lowest in generalized schemes.

The Role of Market Intermediary Type

In addition to reciprocity, the type of intermediary operating within peer-to-peer sharing platforms is expected to play a crucial role in shaping consumers' intentions to share. While a review of current schemes suggests that it is the role of a for-profit market intermediary in most cases to offer a suitable infrastructure for bringing providers and users together, Bardhi and Eckhardt (2012) suggest that sharing schemes may fit different types of market intermediaries, from for-profit (e.g., Airbnb) to non-profit (e.g., Couchsurfing). This study, therefore, contributes over and above this first distinction by introducing not only three forms of reciprocity but also two distinct types of intermediaries that are expected to impact consumers' intentions to provide their private possessions for sharing. As such, it is assumed that consumers are more willing to provide their private goods in peer-to-peer CC schemes where the market intermediary has no intention to make

profit. This is supported by prior literature (Sibai, De Valck, Farrell, & Rudd, 2015), suggesting that interactions within online communities of consumption may match different governance structures that range from market to clan. Market governance is based on the ideas of exchange (profit), transactional interaction, negotiation, and direct reciprocity whereas clan governance obeys principles of sharing (non-profit), communal interaction, peer pressure, and shared identity. It may be assumed, then, based on the literature on CC (Bardhi & Eckhardt, 2012; Decrop & Degroote, 2014; Hellwig, Morhart, Girardin, & Hauser, 2015), that sharing scheme participants are more likely to escape the market and adhere to clan governance. From this theoretical background, it can be suggested that:

H2: A non-profit (for-profit) market intermediary strengthens (weakens) consumers' intentions to provide their private possessions for sharing.

The Mediating Effect of System Trust and Perceived Risk

Both system trust and perceived risk are involved in social exchange theory: "Since there is no way to assure an appropriate return for a favor, social exchange requires trusting others to discharge their obligations" (Blau, 1964: 94). Indeed, while Finley (2013: 2) suggests that "trust is the enabling factor inherent within all sharing-sector activities," other studies support the idea that a high level of perceived risk may hinder consumers' intention to provide items (Bardhi & Eckhardt, 2012; Gefen, Rao, & Tractinsky, 2003). Molm et al. (2000) suggest that reciprocal exchanges enable trust while negotiated exchanges with binding agreements help to reduce risk. The academic literature provides different conceptualizations of the relationship between the two constructs of trust and risk (for a review, see Gefen et al., 2003). In light of a plethora of studies on e-commerce that demonstrate that trust and risk affect behavior independently (Gefen, 2000; Chircu, Davis, & Kauffman, 2000), the present paper assumes two distinct routes to explain the effects of reciprocity and market intermediary type on consumers' intention to provide possessions for sharing (see Figure 1), i.e., consumers' level of system trust (emotional/affective route) and of perceived risk (rational/cognitive route).

Molm and colleagues (2000) contend that all forms of social exchange involve a certain level of uncertainty and risk. Much of this uncertainty vanishes, however, once partners agree on the terms of an exchange. This suggests that perceived risk is likely to be higher for generalized reciprocity, where participants "initiate exchange

without knowing what they are getting in return, and with no guarantee of the other's reciprocity" (Molm, Takahashi, & Peterson, 2000: 1400), than for balanced reciprocity, where providers are aware of a specific return for their provision. In line with the assumptions of social exchange, then, a transaction that receives no compensation in return will naturally evoke a higher perception of risk. Money, in contrast, is generally presented as the best way to reduce perceived risk in reciprocal exchange: "the existence of money guarantees a static double coincidence of wants and therefore supports the efficient trade of contractible goods in all instances" (Prendergast & Stole, 2001: 1); it is also likely to facilitate social exchange in non-contractible services (as is the case with many CC schemes) through the use of voluntary transfers. Simmel (1990) suggests that money affords the precision and calculability in social relations which support personal autonomy. Ikkala and Lampinen (2015: 9) argue further in the framework of peer-to-peer accommodation that "the presence of clear-cut monetary transactions may contribute to hosts' sense of control by making it easier for the exchange partners to adopt a shared definition of the exchange situation." In line with such arguments, then, this paper suggests that:

H3a: Reciprocity type influences the level of perceived risk when providing assets in sharing schemes, with balanced (monetary) reciprocity being more effective than generalized reciprocity in reducing risk.

H3b: Perceived risk negatively impacts consumers' intentions to provide their private assets for sharing.

Trust, on the other hand, appears to play a major role in providing assets for sharing and was referred to as "the key to the potential market for nonownership services" (Ndubisi, Ehret, & Wirtz, 2016: 262). A large number of authors (Bialski, 2009; Decrop & Degroote, 2014; Finley, 2013; Ikkala & Lampinen, 2015) have carried out ethnographic research showing that trust is a key factor in enabling participation in hospitality networks such as Airbnb and Couchsurfing. In a study done in the U.S., 67% of respondents in a survey conducted for Campbell Mithun expressed trust concerns as the primary barrier to using a sharing economy platform (Campbell Mithun, 2012). Trust in the system has become, in the environment of "digitally mediated sharing" (Rudmin, 2016: 198), a pivotal factor for enabling transactions between unknown peers, transactions that do not have a concrete

reference point at the time the decision was made to provide assets for sharing. Indeed, Benlian and Hess (2014) demonstrate a positive relationship between system trust and participation in online communities. Thus, as novel peer-to-peer schemes rely mainly on digital platforms to bring together users and providers who are unfamiliar with each other, the present study extends previous assumptions by expecting the level of trust in the system to be particularly decisive in predicting consumers' intentions to provide their private assets for sharing. More specifically, it assumes that consumers are likely to prefer non-profit market intermediaries for peer-to-peer transactions as peers tend to be trusted more and the overall credibility of commercial cues is generally lower than that of non-commercial sources of information (Nolan, 1976). Thus:

H4a: Market intermediary type influences the level of system trust when it comes to providing assets in sharing schemes, with non-profit schemes being more trusted than for-profit intermediaries.

H4b: System trust positively impacts consumers' intentions to provide their private possessions for sharing.

The paper's conceptual framework and major hypotheses are summarized in Figure 1.

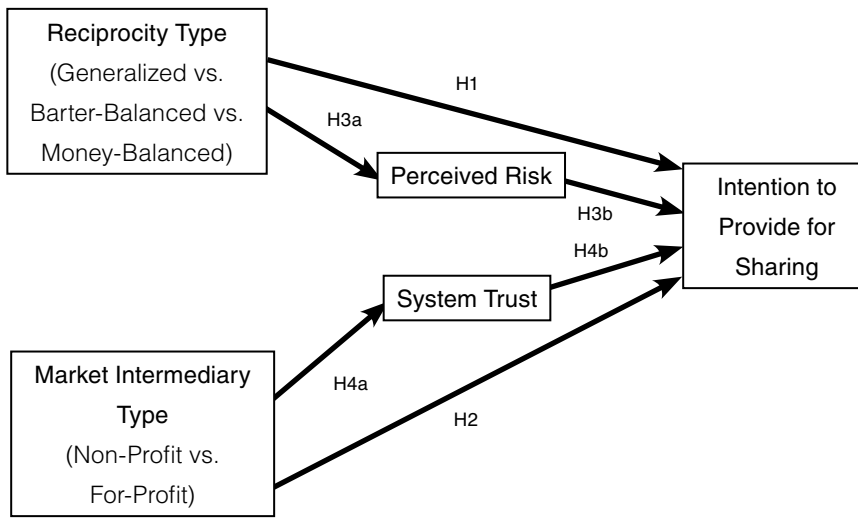

Figure 1: Conceptual framework.

METHODS AND RESULTS

Study 1

In our first study, we developed an experimental design which allowed us to examine the different effects of the three forms of reciprocity (generalized vs. barter-balanced vs. money-balanced) on the intention to provide one's personal assets for sharing. Three different text-based stimuli were deployed; these included a short description of a peer-to-peer sharing system that involved access to tangible items such as household appliances and tool kits (e.g., a drill, a tent, and a bike) from other peers over an online sharing platform.

The general description of the sharing system, which was inspired by real-life examples of online sharing platforms (e.g., neighbourgoods.com), was held constant while the type of reciprocity was manipulated by describing three different forms of compensation that the sharing system would offer to the providers of the objects (example scenarios can be found in the appendix). Respondents who were exposed to the generalized reciprocity condition of the vignette were led to believe that "the participant that provides the object(s) would not get any compensation for such sharing, that the provision would be completely for free." Respondents for the barter-balanced reciprocity condition read that "as compensation for such sharing, the participant that provides the object(s) would have the option to similarly borrow some of the selected objects that other members have available for short-term lending." The third type of reciprocity, presented as money-balanced, involved the following description: "As compensation for such sharing, the participant that provides the object(s) would receive the payment of a pre-defined monetary fee." Following exposure to the text-based stimuli, participants rated their intentions to provide assets in the sharing system on a single item, 7-point Likert scale question ranging from "1 = *very unlikely"* to "7 = *very likely*."

A sample of 340 U.S. participants was recruited online with the help of Amazon's crowdsourcing platform Mechanical Turk where respondents voluntarily answered a requested survey against compensatory payment ($1.00). Three hundred and sixteen subjects were left for the analysis (146 female, Mage=38.1) after respondents who failed attention checks regarding the stimuli were removed. To test the effect of reciprocity on the intention to provide one's assets for sharing, regression analysis with the independent variable *reciprocity* (contrast coded: generalized [1] vs. barter-

balanced [2] vs. money-balanced [3]) was conducted. The analysis revealed a significant main effect of the reciprocity manipulation on the dependent variable (MGeneralized = 3.62 vs. MBarter-Balanced = 4.22 vs. MMoney-Balanced = 4.82; F[1,315]=11.01, p=.000). Results of the pairwise comparison analysis via Post-Hoc-Test under the assumptions of Tukey HSD show significant differences between the groups of generalized and barter-balanced reciprocity (p=.045), generalized and money-balanced reciprocity (p=.000), and money-balanced and barter-balanced reciprocity (p=.040). Participants reported the weakest intentions to provide their personal belongings to other consumers in the CC scheme when they expected to receive no compensation and were most eager to participate as providers against the payment of a monetary fee.

Study 2

A second study was designed to extend the experimental design of Study 1 by introducing a second scheme characteristic, i.e., the type of market intermediary, next to reciprocation as explained in Figure 1. A 3x2 between-subjects' design (reciprocity: generalized vs. barter-balanced vs. money-balanced; market intermediary: profit vs. non-profit) was subsequently created.

The reciprocation stimuli of Study 2 conceptually replicated those designed for Study 1. A second manipulation was then introduced, one that altered the market intermediary type of the sharing scheme by describing that "the system is managed by a commercial company that wants to make profit with the scheme" (for profit) versus that "the system is managed by a team of volunteers who do not want to make profit with the scheme" (non-profit). The constructs of system trust and perceived risk were introduced as potential mediators of the assumed effect of the two independent variables on the intention to provide assets for sharing (Molm et al., 2000). Measures of intention to provide were identical to those of Study 1 and were followed by two item batteries assessing the degree to which respondents perceived the sharing system as trustworthy (4 items, adapted from Benlian & Hess, 2011) and as entailing a potential risk (3 items, adapted from Jarvenpaa, Tractinsky, & Vitale, 2000). Levels of system trust were indicated on four scales ranging from "1 = *very unlikely*" to "7 = *very likely*" and included statements such as "I believe that the sharing system would act in my best interest." Perceived risk was measured on scales ranging from 1 (significant opportunity, high potential for gain, very positive situation) to 10 (significant risk, high potential for loss, very negative situation).

Following a procedure similar to that of Study 1, 317 respondents (130 female, Mage = 35) recruited using Amazon's Mechanical Turk were left for analysis after 21 were removed from the sample due to failure of attention checks regarding the stimuli. A small monetary reward ($1.00) was given for their participation.

Respondents from the self-selecting sample were randomly assigned to one of the six experimental conditions. The results of the regression analysis replicated the significant main effect found in Study 1 (MGeneralized = 3.59 vs. MBarter-Balanced = 3.93 vs. MMoney-Balanced = 4.25; F[1,316]=6.952, p=.009). Further results revealed a significant main effect of market intermediary type on intentions to provide assets for sharing (F[1,316]=6.525, p=.011). These show a stronger intention to participate as a provider when the sharing scheme is managed by a team of volunteers than when it is mediated by a for-profit company (MProfit = 3.66 vs. MNon-Profit= 4.16).

Two mediation analyses (Preacher & Hayes, 2008) were then performed to test whether system trust was able to mediate the effect of market intermediary type on the intention to provide one's private belongings for sharing and if perceived risk was able to mediate the effect of reciprocity type on the same. The two hypothesized routes—via affective and cognitive processing—were thus analyzed following the INDIRECT mediation analysis approach, applying 5000 bootstrapping samples and a confidence interval of 95% (Preacher & Hayes, 2008). The results confirmed the presented theorizing: system trust mediates the effect of market intermediary on intentions while perceived risk mediates the effect of reciprocity type on intentions. Decreased perceptions of risk and increased trust in the system thus influence stronger intentions to provide a product for sharing. A summary of the results of the mediation tests of Study 2 is illustrated in Figure 2.

CONTRIBUTIONS

Research on the collaborative aspects of the sharing economy is scarce for now but is developing rapidly. As a contribution to the growing body of literature on consumer behavior in the sharing economy (e.g., Botsman & Rogers, 2011; Belk, 2014; Finley, 2013), this study offers one of the first initiatives in investigating the *provider's* perspective in consumer-to-consumer collaborative consumption schemes. Its results thus offer both theoretical and managerial contributions toward a better understanding of the sharing economy. From a theoretical perspective, this paper

advances prior literature by identifying system trust and perception of risk as key processes that foster providers' participation in collaborative consumption. The study thus finds that the enhancement of system trust and risk reduction is likely to strengthen consumers' willingness to participate as providers in a sharing platform, thereby extending prior theoretical contributions on the concept of trust and risk to the new peer-to-peer context of collaborative consumption. Moreover, while this study empirically confirms the key role of system trust as a mediating variable that explains the effect of market intermediary type on intention to provide assets for sharing, trust in the providing system itself appears to be a pivotal emotional construct that further insures and increases consumers' intention to participate in peer-to-peer schemes as providers, particularly when a non-profit rather than a for-profit market intermediary is involved. To add to this rationale, perceived risk was identified as a second cognitive construct that explains the nature of the effect of reciprocity type on the intention to provide goods for sharing within a CC scheme. Consumers may indeed weigh the risks (e.g., damaging or loss of shared goods, interpersonal disputes, loss of time, etc.) and benefits (e.g., additional revenue, social interaction, self-enhancement, etc.) of their participation before making their decision.

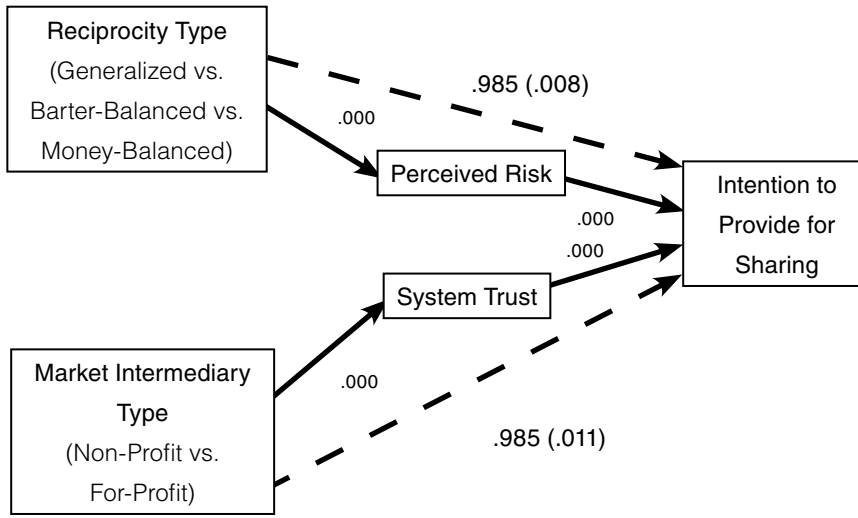

Figure 2: Mediation results of Study 2.

From a managerial perspective, this paper provides evidence for the particular importance of reciprocity and market intermediary types. Based on our findings,

consumers appear to be the most willing to provide their personal belongings for sharing in a CC scheme that relies on a money-balanced reciprocity approach and which at the same time is enabled by a non-profit market intermediary. Results indicate that balanced reciprocity is more attractive from the provider's perspective than is generalized reciprocity while money (e.g., the payment of a monetary fee) has a more positive impact upon intentions to provide for sharing than does barter (e.g., access to another good or service). This suggests that monetization as a standardized economic system of exchange is the most effective way to stimulate participation in CC schemes. In sum, this research indicates that it may be valid for consumer-to-consumer platform managers to foster non-commercial activities and escape the market given that a non-profit scheme is preferable. Despite emphasizing non-profits, however, our results suggest overall that an advantage to the scheme may be to offer compensation rather than be based on the more altruistic idea of generalized reciprocity. A non-profit intermediary and the provision of (monetary) compensation should prove to be more likely both to enhance trust in the system and to reduce the risks involved in participating in the scheme.

From a global sustainability perspective, identifying ways to improve providers' intention to participate in sharing is particularly relevant considering the need to make sustainable practices more widespread by avoiding waste, enhancing the recirculation of products, and reducing new purchases. To foster the availability of underused assets in collaborative consumption exchanges, consumers need to be willing to offer their private assets (e.g., cars, homes, appliances, tools, etc.) for sharing with others. In this light, incorporating monetary compensation in non-profit collaborative consumption schemes offers promising ways for fostering consumer-to-consumer sharing that should in turn increase the *supply* of privately owned, underused assets and reduce material consumption, wasteful behavior, and disposal decisions. Thus, while demand for shared goods and temporary access to cars, holiday accommodations, or tools is paramount as mirrored in the significant growth of the sharing economy (PwC, 2015), sustainability managers need to secure a global *supply* of privately-owned assets to be able to respond to this growing demand.

LIMITATIONS AND FUTURE RESEARCH

This paper entails a series of limitations that pave the way, however, for future research projects. First, the results are based on two samples of respondents from the U.S. who were recruited through Amazon's crowdfunding platform Mechanical Turk and thus may not be representative of the international population of participants in the sharing economy. Second, although the authors tried to develop realistic examples, the scenario-based approach that was used to manipulate reciprocity and market mediation may have appeared to be too abstract for some respondents. Third, the originality of this work was to focus on consumers as *providers*, yet C2C sharing schemes may be regarded from the perspectives of both users and providers. A next step, then, that may nonetheless prove worthwhile could include investigating consumers as users within the proposed framework. Finally, only one exemplary case of CC (i.e., a C2C local sharing scheme involving personal possessions) was investigated in this paper, thus leaving room for exploring other B2C and C2C sharing systems that involve other goods or services.

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APPENDICES

Variable	Operationalization	C.A.
System Trust	I believe that the sharing system would act in my best interest.	0.918
	The sharing system is truthful in its dealings with me.	
	The sharing system would keep its commitments.	
	The sharing system is sincere and genuine.	
Perceived Risk	How would you characterize the decision of whether [or not] to provide some of your objects in the sharing system described above?	0.846
	Significant opportunity-Significant risk	
	High potential for loss-High potential for gain*	
	Very positive situation-Very negative situation	
Intention to Provide for Sharing	How likely would you be to provide some of your possessions (objects that you do not use frequently) in the sharing system described above?	N.A.

Appendix 1: Variables and operationalizations. *indicates reverse coding.

		Mean	SD	1	2	3
1	Intention	3.92	1.83	1.000	.700**	-.698**
2	System Trust	4.48	1.25		1.000	-.724**
3	Risk	4.39	1.30			1.000

Appendix 2: Means, standard deviations, and Pearson-correlations for Study 2.
** Correlation is significant at the 0.01 level (2-tailed).

1) Imagine that a new sharing system is introduced in the city you live in. It allows participants to share some of their objects (e.g., a drill, a tent, a bike) with each other through the Internet. Participants upload pictures of the specific objects they own and want to share with other members on the sharing platform. Members who participate in the sharing system can then easily see the objects that other members have to offer and borrow them. The system is managed by a commercial company that wants to make a profit with the scheme.

If you want to participate as a provider, you can opt to provide objects that you own and do not use frequently to the members of the commercial sharing system for short-term lending over the sharing platform (e.g., for one day). The participant that provides the object(s) will not get any compensation for such sharing; the provision would be completely for free.

2) Imagine that a new sharing system is introduced in the city you live in. It allows participants to share some of their objects (e.g., a drill, a tent, a bike) with each other through the Internet. Participants upload pictures of the specific objects they own and want to share with other members on the sharing platform. Members who participate in the sharing system can then easily see the objects that other members have to offer and borrow them. The system is managed by a commercial company that wants to make a profit with the scheme.

If you want to participate as a provider, you can opt to provide objects that you own and do not use frequently to the members of the commercial sharing system for short-term lending over the sharing platform (e.g., for one day). As compensation for such sharing, the participant that provides the object(s) would have the option to similarly borrow some of the selected objects that other members have available for short-term lending.

3) Imagine that a new sharing system is introduced in the city you live in. It allows participants to share some of their objects (e.g., a drill, a tent, a bike) with each other through the Internet. Participants upload pictures of the specific objects they own and want to share with other members on the sharing platform. Members who participate in the sharing system can then easily see the objects that other members have to offer and borrow them. The system is managed by a commercial company that wants to make a profit with the scheme.

If you want to participate as a provider, you can opt to provide objects that you own and do not use frequently to the members of the commercial sharing system for short-term lending over the sharing platform (e.g., for one day). As a compensation for such sharing, the participant that provides the object(s) will receive payment of a pre-defined monetary fee.

Appendix 3: Scenario examples for Study 2.

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EL PROBLEMA MÁS IMPORTANTE QUE TENEMOS

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En 1986, Richard Hamming, un científico e innovador intelectual muy respetado, dio un discurso en el *Bell Labs Morris Research and Engineering Center* en Morristown, N.J., donde recordó de una serie de comidas en ciertos laboratorios, en que comenzaba preguntando: "¿Cuáles son los problemas más importantes de su campo?" Después de una semana les preguntó "¿Qué problemas importantes están abordando ustedes?" Y después de algún tiempo, entró un día y dijo "Si lo que están haciendo no es importante, y piensan que no llevará a algo importante ¿por qué están en los laboratorios Bell trabajando sobre eso?" (Hamming, 1986)

Las preguntas de Hamming no solo se deben plantear a los científicos de uno de los mejores centros de investigación del mundo de todos los tiempos. "¿Cuál es el problema más urgente que enfrentamos hoy en día? ¿Estamos en ello? Y si no, ¿por qué no lo estamos haciendo?"—son palabras apropiadas para cada uno de nosotros para el poco tiempo que tenemos, afortunados de estar en este planeta tan bonito.

Teniendo en cuenta la historia de los jesuitas y su tradición de "cambiar el mundo" a través de la educación inspirada en innovaciones sociales repetidas (Lowney, 2003), las universidades jesuitas y sus escuelas de negocios están invitadas sobre todo a explorar tales preguntas y descubrir, haciéndolo, las preguntas más importantes que tenemos. Es cierto que el Papa Francisco en *Laudato Si'* (Francisco, 2015) tiene muy pocas dudas sobre el desafío más urgente que todos, nuestra especie incluso, enfrentamos. Nos pide—en una encíclica muy diferente porque se dirige no solo a los católicos o a los cristianos sino a todos en este planeta—que entablemos un diálogo sobre el rumbo económico, medioambiental, social y cultural, claramente dañino y potencialmente catastrófico en el que nos embarcamos como especie;

y de ese diálogo, descubrir cómo podemos contribuir a mejorar la trayectoria de nuestras acciones.

Un año después de la publicación de *Laudato Si'*, Paul Krugman, Premio Nobel, también tenía pocas dudas sobre el problema más urgente al que nos enfrentamos, sobre todo si consideramos los asuntos de política global como indicadores de las preocupaciones más importantes de nuestra especie:

> El año pasado fue el más caliente registrado, por un amplio margen; ello debería (aunque no lo hará) poner fin a las afirmaciones de los negadores del clima de que el calentamiento global ha cesado. La verdad es que el cambio climático sigue asustándonos. Es, con creces, el tema político más importante que enfrentan América y el mundo. (Krugman, 2016)

Hace algunos meses, Bill McKibben, uno de los "canarios en la mina de carbón" de la insostenibilidad global desde hace mucho tiempo y también autor de numerosos libros que incluyen *The End of Nature* (1989) (El fin de la naturaleza) y *Eaarth: Making a Life on a Tough New Planet* (2010) (Eaarth: Viviendo en un planeta nuevo y duro), hizo esta pregunta alarmante en el subtítulo de su nuevo libro *Falter* (2019) (Flaquear): "¿Ha empezado el juego humano a desarrollarse hasta el final?". Jared Diamond, quizás más conocido por su obra *Guns, Germs, and Steel: The Fates of Human Societies* (1999) (Armas, gérmenes y acero: La sociedad humana y sus destinos) y autor de *Collapse: How Societies Choose to Fail or Succeed* (2005) (Colapso: Por qué unas sociedades perduran y otras desaparecen), reseñó el libro de McKibben en un artículo en el *New York Times Book Review* con fecha del 21 de abril, 2019. Notó que

> en la primera mitad del libro [McKibben] explica los peligros actuales de la civilización que incluyen el riesgo de una guerra nuclear y también los riesgos múltiples asociados con el cambio climático: el aumento del dióxido de carbono en la atmósfera, las amenazas a la producción de alimentos, el aumento del nivel del mar, el calentamiento del océano y la acidificación.

Luego, Diamond nota lo siguiente:

> La parte central del libro habla de las fuerzas opuestas a las soluciones a los problemas planteados en la primera parte—motivados de diversas maneras por el interés propio, las realidades sombrías, el poder, los ideales y las opiniones sobre el papel apropiado del gobierno. Estas fuerzas incluyen Exxon, la pobreza, la desigualdad, Ayn Rand, los hermanos Koch, otros estadounidenses muy ricos, el presidente Trump y Silicon Valley.…

> Finalmente, en la última parte del libro, McKibben ofrece sus motivos de esperanza. Entre los más destacados están los paneles solares, que ofrecen energía renovable barata en todo el mundo, y los movimientos no violentos, cuyos exitosos activistas contra las oposiciones arraigadas y bien armadas han incluido a Gandhi, Martin Luther King Jr., los manifestantes del Día de la Tierra y al propio grupo de McKibben, 350.org.

Diamond concluye su reseña tan rica y valiosa con el párrafo siguiente:

> Se requerirán muchas voces diferentes para convencer a los diversos ciudadanos y empresas del mundo a colaborar para resolver los problemas más grandes del mundo. La voz de McKibben ha tenido influencia. Espero que su nuevo libro fortalezca la motivación de los que se solidarizan con su punto de vista. Me temo que no vaya a convencer a los que no los creen. Espero que mi primera predicción sea correcta y la segunda, no. (Diamond, 2019)

La semana siguiente, John Lanchester (2019) escribió que el cambio climático "es el mayor desafío al que la humanidad se enfrenta colectivamente" en la primera frase de su reseña en el *Times* de dos otros nuevos libros (Wallace-Wells, 2019; Rich, 2019).

¿ENTONCES QUÉ?

Al enfrentarse a las realidades de las situaciones recientes, actuales y futuras, los editoriales y artículos del *Journal of Management for Global Sustainability* nos han invitado a menudo a "afrontar los hechos brutales sin perder la fe," citando a Jim Collins (Collins, 2001) y seguirán haciéndolo, quizás de una manera más fuerte y estridente en el futuro.

Lo aterrador de las perspectivas que sugieren que el cambio climático y la insostenibilidad global son "amenazas existenciales" es que no estamos hablando de las obras de autores como Camus, Kierkegaard y Sartre; estamos hablando de las amenazas a la misma existencia de nuestra propia especie. Una de las principales aportaciones de *Laudato Si'* es cómo el Papa Francisco declara franca y directamente que la insostenibilidad global es un asunto moral y que los daños que estamos haciendo ahora a los más vulnerables y a las generaciones futuras son errores morales de la mayor magnitud. Las formas que hemos elegido para producir y consumir los bienes y lujos de nuestras vidas y cómo distribuimos los beneficios y costos de esos procesos de producción-consumo-distribución contribuyen al carácter insostenible

de nuestra situación actual. Todos somos parte del problema de la insostenibilidad global, e incluso las escuelas de negocios también forman parte del problema.

El énfasis claro de *Laudato Si'* en la inmoralidad de nuestras contribuciones para crear un presente insostenible para muchos y un futuro inhóspito para todos es pertinente al estado actual de la enseñanza, la investigación y en particular, la conceptualización de los miembros de las escuelas de negocios jesuitas. De hecho, incluso si la educación en management de los jesuitas puede ser ligeramente mejor que el promedio cuando se trata de abordar cuestiones de insostenibilidad global, sería difícil defender la afirmación de que la enseñanza dominante en marketing, finanzas y contabilidad en las instituciones jesuitas es muy diferente de la que se encuentra en otras escuelas. Dejando a un lado el curso ocasional en marketing verde o marketing "en la base de la pirámide," sería muy difícil afirmar que los cursos en finanzas, marketing, contabilidad, economía, administración, operaciones, comunicaciones, negociación, leyes y quizás incluso ética en todas las escuelas de negocios, incluidas las jesuitas, no se dedican principalmente a brindarles a nuestros estudiantes las habilidades y actitudes para "tomar-desperdiciar-desperdiciar-rápido-y-más rápido-para-los-ricos-y-más ricos" y sentirse muy bien sobre ellos mismos mientras lo hacen.

Al reconocer que la insostenibilidad global es, en su esencia, un problema moral de la mayor magnitud y no solo un problema empresarial, todas las universidades y sus escuelas de negocios tienen la obligación y la oportunidad de comportarse de manera que les permita dejar de contribuir al problema y empezar a convertirse en medios para encontrar soluciones. La red mundial de escuelas de negocios jesuitas, en particular, está especialmente diseñada para explorar las realidades de nuestra situación actual, reflexionar sobre esas realidades y nuestros recursos para realizar contribuciones positivas y tomar medidas que puedan impactar no solo a las instituciones educativas sino también al mundo.

Arthur Taylor, cuando fue decano de la Escuela de Negocios de Posgrado de la Universidad de Fordham desde finales de los 80 hasta principios de los 90, invitó una vez a Roland Christensen, el experto en la enseñanza de casos en la Escuela de Negocios de Harvard (Harvard Business School o HBS), a participar en un retiro de profesores y dirigir una sesión sobre la enseñanza de casos. A Frank Werner, que

había sido alumno de Christensen en HBS, se le pidió que hospedara a Christensen durante la visita.

Al final del viaje, Frank le notó a Roland, mientras le conducía al aeropuerto para su vuelo de regreso, que debía de recibir muchas invitaciones de este tipo, y le preguntó por qué había aceptado esta. Christensen respondió que Frank estaba en lo cierto acerca de las invitaciones y que le había preguntado a su decano si debía aceptar esta cuando la recibió. Su decano dijo que sí, que sería bueno aceptarlo porque un área en la que la HBS podría ser competitivamente vulnerable estaba relacionada de alguna manera con el propósito y significado más profundo de las organizaciones empresariales y la educación: un área a la que la espiritualidad y la religión podrían tener un acceso especial. Tenía curiosidad, por lo tanto, por lo que Fordham podría estar haciendo como una escuela de negocios creyente en un área donde la HBS podría ser vulnerable.

Cuando Frank le preguntó a Roland qué había aprendido durante su visita sobre lo que Fordham estaba haciendo en ese dominio, Christensen respondió: "No mucho."

Fordham, desafortunadamente, no estaba aprovechando sus valores y patrimonio jesuitas para promover la transformación de la educación e investigación en management. Está claro que en términos de innovación para la transformación de la educación en management, la respuesta de Christensen probablemente fue cierta para prácticamente todas las escuelas de negocios, las que son creyentes y las que no. Y es probable que todavía sea cierto hoy en día, cuando la necesidad de transformar la educación en management es aún mayor debido a que nuestra situación es mucho más grave.

Tres décadas después de la conversación de Christensen y Werner, la necesidad de transformaciones profundas, impulsadas por la insostenibilidad global, en qué y cómo producimos, distribuimos y consumimos tal como se sugiere en *Laudato Si'* ofrece muchas oportunidades para que las escuelas de negocios jesuitas proporcionen respuestas dramáticamente diferentes para la pregunta que Roland Christensen estaba explorando. Son respuestas que podrían encender el fuego que transformará la educación en management en todo el mundo.

¿Y AHORA QUÉ? UNA SEGUNDA OPORTUNIDAD PARA LAS ESCUELAS DE NEGOCIOS JESUITAS

Las escuelas de negocios jesuitas han planteado, de varias maneras muy significativas, enfoques y acciones pioneras que han contribuido activamente y siguen contribuyendo a construir un mundo más justo y sostenible. Los compromisos con la justicia social y la lucha contra la pobreza, por ejemplo, han sido focos importantes en prácticamente toda la educación en management jesuita. Los centros y programas para la sostenibilidad global están ubicados en varios campus, y las escuelas han sido líderes sobresalientes en los dominios de la innovación social y el emprendimiento social. La Asociación Internacional de Escuelas de Negocios Jesuitas (International Association of Jesuit Business Schools o IAJBS) tomó un compromiso profundo con la sostenibilidad global en 2009. Aunque las muchas otras actividades similares son demasiado numerosas para enumerarlas aquí y no deben minimizarse ni pasarse por alto, aún quedan por delante otras oportunidades interesantes que aún no se han aprovechado. Se hablará de tres de ellas a continuación. Si bien son atractivas para las escuelas miembros y los claustros de IAJBS y CJBE (Colleagues in Jesuit Business Education; Colegas en la Educación Empresarial Jesuita) en particular, sin embargo, también presentan oportunidades interesantes para todas las escuelas de negocios. Después de analizar estas tres áreas de oportunidad, proporcionaremos una breve introducción a los artículos en este número de la revista.

EL FORO MUNDIAL DE LA IAJBS

La IAJBS reconoció esta amenaza existencial hace diez años cuando su 15º Foro Mundial se reunió en el Xavier Labor Relations Institute (XLRI; Instituto de Relaciones Laborales Javier) en Jamshedpur, Jharkhand, India. Aquel foro mundial, cuyo tema era el liderazgo para la sostenibilidad, era diferente en un grande, y quizás único, aspecto—se presentó una resolución, aprobada por unanimidad y ratificada al día siguiente por la Junta Ejecutiva de la IAJBS. La resolución pidió que el Foro Mundial se dedicara durante los próximos diez años al tema general de contribuir a un mundo más sostenible. Luego, en el Foro Mundial en la Universidad Ateneo de Manila en Manila el año siguiente, Rudy Ang y sus colegas de la IAJBS propusieron que la organización creara una revista sobre la sostenibilidad. El primer número de esa revista, la *Journal of Management for Global Sustainability* (Revista de Gestión para la Sostenibilidad Global) se publicó en 2013.

Durante la última década desde 2009, las palabras que se usan para describir el objetivo de lograr un mundo sostenible han evolucionado desde los conceptos de sostenibilidad, desarrollo sostenible, sostenibilidad global y florecimiento. Ahora, quizás, podemos agregar "regeneración," que se refiere no solo a hacer menos daño o ningún daño, sino a restaurar nuestro mundo roto, "cuidar nuestra casa común," como lo diría el Papa Francisco. La definición de sostenibilidad ofrecida en el primer número de esta revista, de manera bastante interesante, abordó explícitamente la necesidad de "curar nuestro mundo roto" sustituyendo las palabras "sin comprometer" tal como se encuentran en la definición popular de desarrollo sostenible de la Comisión Brundtland con la frase "mientras se mejora."

> *Definimos la sostenibilidad global como … un proceso que satisface las necesidades de la generación actual al tiempo que mejora la capacidad de las generaciones futuras para satisfacer sus propias necesidades. La sostenibilidad global visualiza un mundo que funciona para todos, sin que nadie se quede fuera.* (Stoner, 2013: 2).

El 25º Foro Mundial se reunirá en julio de 2019, esta vez en el Xavier Institute of Management (XIMB; Instituto de Gestión Xavier) en Bhubaneswar, India. También servirá como la reunión inaugural de la Sección Regional de Asia del Sur de los Colegas en la Educación Empresarial Jesuita. El tema de este foro, "Innovar y florecer," sigue la definición de sostenibilidad de John Ehrenfeld como "la posibilidad de que la vida humana y de otro tipo florezca en el planeta para siempre" (Ehrenfeld, 2009).

Dado que la reunión de 2019 se cumple en el décimo aniversario del compromiso asumido en la conferencia XLRI en 2009, es muy probable que se ofrezca una nueva resolución invitando al Foro Mundial a comprometerse de nuevo a otros diez años de liderazgo para un mundo sostenible, o tal vez comprometerse con un mundo regenerativo.

El Foro Mundial IAJBS no es, por supuesto, la única conferencia anual que históricamente ha elegido un tema nuevo y diferente cada año. De hecho, casi todas las conferencias lo hacen. Sin embargo, al igual que el Foro Mundial marcó un hito al comprometerse durante diez años con el tema del liderazgo para la sostenibilidad, otras organizaciones profesionales o incluso fundaciones importantes pueden tomar compromisos similares para centrar sus energías y las nuestras en "el mayor desafío de la humanidad." Solo en el ámbito de las organizaciones profesionales para académicos de gestión, por ejemplo la Academy of Management, la Eastern

Academy of Management y las demás, la conferencia de gestión y de conducta organizativa y otras podrían enviar la señal al mundo de que los problemas del cambio climático e insostenibilidad global ya no deben ser ignorados y que sus miembros van a prestarles la atención que han merecido por mucho tiempo pero que no han recibido. Y tal vez también las principales fundaciones, como la Fundación Bill y Melinda Gates, la Fundación MacArthur, la Fundación Ford, la Fundación Susan Thompson Buffett y otras, harán compromisos similares a largo plazo para reunir los recursos que necesitamos para inspirar, financiar y honrar a aquellos que estén dispuestos y ansiosos por hacer lo que se debe hacer si nosotros y nuestros hijos queremos tener un futuro digno.

NUESTRA TRANSFORMACIÓN Y LA EDUCACIÓN DE NEGOCIOS

Si buscamos dos transformaciones importantes que nuestra especie pueda necesitar para enfrentar nuestra situación actual de insostenibilidad global, para avanzar hacia un futuro floreciente y regenerativo, una de ellas puede ser a nivel individual y la otra a nivel de sistemas. Como individuos, es posible que emprendamos la "conversión ecológica" que el Papa Francisco pide en *Laudato Si'*. Es posible que tengamos que convertirnos en personas diferentes como productores, consumidores y ciudadanos. A nivel de sistemas, es posible que tengamos que transformar el sistema defectuoso de producción, distribución, consumo que sirve a gran parte del mundo de manera tan deficiente ya que está destruyendo la capacidad del planeta para sustentar nuestra propia especie y otras.

¿Cómo lograremos estas transformaciones? La red de escuelas de negocios jesuitas podría proporcionar valiosas contribuciones al mundo en estos dos campos.

EXPLORANDO LAS TECNOLOGÍAS PARA UNA CONVERSIÓN ECOLÓGICA

Hay cierta ironía en el hecho de que estamos invirtiendo miles de millones de dólares para investigar una variedad de tecnologías que aborde los problemas de nuestro sistema productor-distribuidor-consumidor, pero casi nada para explorar cómo podemos convertirnos en el tipo de personas que utilice esas tecnologías para crear un mundo sostenible / floreciente / regenerativo. No estamos haciendo

inversiones a gran escala para descubrir cómo podemos transformarnos; de hecho, estamos haciendo inversiones en tecnología de punta a nivel de sistemas en un momento en que muchos observadores creen que ya tenemos toda la tecnología que necesitamos para crear un mundo sostenible (p.ej. los 100 proyectos mencionados en la obra de Paul Hawken: *Drawdown: The Most Comprehensive Plan Ever Proposed to Reverse Global Warming* [Drawdown: el plan más completo jamás propuesto para revertir el calentamiento global (2018)]) y el enfoque integrado para transformar la economía global utilizando las tecnologías existentes como se describe en *A Finer Future: Creating an Economy in Service to Life* (Un futuro mejor: Creando una economía en servicio a la vida) por Lovins, Wallis, Wijkman y Fullerton (2018). El problema es que no estamos aprovechando las tecnologías que ya tenemos.

Si nos liberamos de pensar automáticamente en la tecnología como algo mecánico, a menudo incorporado en la maquinaria y orientado hacia la producción de productos físicos, y en cambio recordamos que podemos definirla simplemente como "un proceso para hacer algo" o como "un sistema mediante el cual la sociedad proporciona a sus miembros las cosas necesarias o deseadas" (Your dictionary, n.d.), es posible aceptar la invitación a invertir de manera sustancial para descubrir cómo utilizar con mayor eficacia nuestras tecnologías de transformación personal de siglos y milenios existentes, así como descubrir otras nuevas.

Podemos buscar formas para hacer que esas tecnologías de transformación sean más efectivas, rápidas y ligeras para quienes las comparten, las adquieren y las utilizan. Y podemos buscar formas de inventar nuevas tecnologías. Podríamos observar, por ejemplo, que los ejercicios espirituales de San Ignacio, algo cercano a las instituciones jesuitas, pueden considerarse como una tecnología de transformación personal y espiritual de cinco siglos de antigüedad, que se ha mostrado útil repetidamente. La tentación de explorar tecnologías muy prometedoras de transformación personal, por lo tanto, puede ser bastante atractiva dado que muchos miles de millones ya están invirtiendo en la búsqueda de tecnologías a nivel de sistemas destinadas a cambiar nuestras formas de producir, distribuir y consumir.

Cuando nos enfocamos en nosotros mismos y en nuestras formas de estar en el mundo, también es tentador pensar en invertir una cantidad de dinero apreciable en la creación de una serie de centros de investigación innovadores que analizarán las tecnologías de transformación personal. Los Centros de Acción e

Investigación en Tecnologías Transformacionales (Centers for Action and Research into Transformational Technologies o CARTT) son casi una marca que puede mejorarse enormemente. Sin embargo, independientemente de lo que decidamos mejorar, podría ser valioso observar, a través de la lente de la tecnología, experiencias de transformación sólidas y bien establecidas, como los Ejercicios Espirituales de San Ignacio, el yoga, la meditación, las prácticas de atención plena y la investigación apreciativa, el conjunto de programas e iniciativas de Ashoka U, el conjunto de programas de Landmark Education y muchos otros que brindan un cambio positivo, profundo y duradero en la vida de las personas y en las formas de ser en el mundo. Y luego están surgiendo enfoques que también pueden ser dignos de una exploración seria, como la Teoría U (p. ej., Scharmer, 2016), Gestión humanística (p. ej., Pirson, 2017) y Liderazgo cuántico (Tsao y Laszlo, 2019).

Existe una posibilidad emergente de que uno o más de estos centros puedan comenzar pronto. De hecho, podría ser particularmente atractivo explorar tecnologías de transformación personal en universidades creyentes, tanto jesuitas como de otro tipo, dado que muchas de estas tecnologías centenarias para transformarnos como seres humanos surgen de y / o están basadas en formas espirituales de estar en el mundo. Las universidades creyentes se sentirán en casa ayudando a descubrir qué es lo que hace que estas tecnologías tengan el impacto que tienen, cómo podemos ponerlas a disposición de más pueblos del mundo, cómo podemos hacerlas más baratas, más rápidas, mejores, y muy importante, cómo podemos protegernos de y prevenir su mal uso.

EL LIDERAZGO EN LAS ESCUELAS DE NEGOCIO

En "Entre dos paradigmas: una lucha por el alma de las escuelas de negocios," Chris Laszlo, Robert Sroufe y Sandra Waddock (*Torn Between Two Paradigms: A Struggle for the Soul of Business Schools*, 2017) piden actuar para transformar la narrativa neoliberal que domina, en gran medida, la enseñanza de management en el mundo. Como se ha señalado en esta revista y en otras partes, el sistema global de producción, distribución y consumo, que es omnipresente, auto-referente, internamente coherente y ambientalmente destructivo, está tan arraigado y tan completamente integrado que parece inmune a cualquier esfuerzo por cambiarlo. Sin embargo, dado que también es tan complejo e interconectado, hay un número

aparentemente infinito de lugares en los que se puede entrar en el sistema y, con suerte, interrumpirlo con fines positivos.

Con el objetivo de convertir la educación empresarial en un vehículo para transformar todo nuestro sistema global de producción-distribución-consumo, la solicitud IAJBS / CJBE para el concurso de la Fundación MacArthur *100&change* en 2016 fue solo una de las muchas posibilidades. El 2 de junio de 2016, la Fundación MacArthur anunció un concurso de 100 millones de dólares estadounidenses para resolver un problema social importante. La posibilidad de que las escuelas de negocios jesuitas participaran en el concurso se discutió brevemente durante la reunión de negocios del CJBE el 10 de julio en Le Moyne College en Syracuse, Nueva York. Una semana después, en el 23º Foro Mundial de la IAJBS en Nairobi, Kenia, se aprobó la siguiente resolución por unanimidad—que fue aprobada al día siguiente por la Junta Ejecutiva de la IAJBS:

> La reunión anual de la IAJBS solicita a los líderes de la IAJBS, a la dirección del CJBE y al resto de la red de escuelas de negocios jesuitas que trabajen juntos para participar en el concurso de 100 millones de dólares llamado *100&change* de la Fundación MacArthur con un proyecto para transformar la educación empresarial jesuita para que esté completamente alineada con la sabiduría de *Laudato Si'*, con nuestros principios educativos jesuitas universalmente válidos, y con la necesidad de la sostenibilidad global, la justicia social y la lucha contra la pobreza. (18 de julio 2016)

El 2 de octubre de 2016 se presentó a la Fundación MacArthur una propuesta para utilizar la transformación de la educación jesuita y de toda la educación en management como un vehículo para transformar nuestro sistema global de producción-distribución-consumo. Hay un poco de ambigüedad con respecto a cómo se cuentan las distintas solicitudes, pero en una cuenta el número es 1,407. Según este recuento, la de IAJBS / CJBE fue una de las 1.406 solicitudes que no ganó el premio de 100 millones de dólares.

La fecha límite para la presentación de candidaturas al concurso 100&change de 2019 finaliza en agosto de 2019. Actualmente se están realizando esfuerzos para redactar una nueva solicitud que sea muy parecida a la original de 2016. Esta nueva solicitud seguirá invitando a las escuelas jesuitas y otras escuelas de negocios a transformar sus currículos y gran parte de su investigación para alinearlos con las realidades del siglo XXI y las necesidades de un mundo regenerativo. De hecho, la posibilidad de tal solicitud ya se ha descrito en esta revista (Stoner, 2018).

No sería necesario que un miembro del claustro de profesores estuviera en una universidad que gane el premio de la Fundación MacArthur, un evento altamente improbable, para contribuir a la transformación de la educación empresarial y nuestro sistema global de producción, distribución y consumo. Cualquier profesor en cualquiera de las disciplinas de una escuela de negocios puede revisar su programa de estudios con el fin de decidir qué es apropiado para las realidades del siglo XX en comparación con lo que es apropiado para las del XXI, y luego comenzar a hacer ajustes en la manera de enseñar e investigar que reclama las realidades del siglo XXI. De hecho, el profesorado de la Facultad de Negocios Anderson de la Universidad Regis y de la Escuela de Negocios Gabelli de Fordham están comenzando o han estado ocupados en este tipo de investigación. Dado que es difícil justificar la enseñanza de un programa de estudios que es apropiado para el siglo XX y no para el XXI, es muy probable que muchos otros sigan su ejemplo explorando por su cuenta y compartiendo lo que están haciendo y aprendiendo con los demás.

¿CÓMO MARCAR UNA DIFERENCIA? CASI DEMASIADAS OPORTUNIDADES PARA ELEGIR

A medida que se escribía este editorial, el Anderson College of Business anunció una nueva especialización en su programa de Máster en Ciencias en Finanzas y Economía, en colaboración con el Instituto Capital (*Capital Institute*) y otros socios comprometidos en explorar y crear enfoques de finanzas regenerativas a nivel local y global. El programa abordará exactamente los problemas en el sistema financiero global que son un obstáculo para la creación de un mundo sostenible / floreciente / regenerador.

Hay muchas oportunidades para cada uno de nosotros en lo que enseñamos, lo que investigamos, cómo definimos el servicio, lo que elegimos comprar o alquilar, y consumir, en qué invertimos y cómo votamos. Las preguntas difíciles no se refieren a la búsqueda de oportunidades y desafíos, sino a la posibilidad de elegir entre muchas alternativas atractivas. Y sobre cuánto de nuestro tiempo, energía y otros recursos dedicaremos a las selecciones que hacemos.

Sabemos cuál es el problema. La pregunta es lo que haremos cada uno de nosotros al respecto.

Y AHORA HABLEMOS DE LOS ARTÍCULOS EN ESTE NÚMERO DE LA REVISTA

Cada uno de los cinco artículos en este número proporciona maneras de que el cambio y la transformación a nivel personal y / o de sistemas pueden contribuir a un mundo más sostenible.

Bernard Arogyaswamy argumenta que, si bien la innovación a menudo crea una ventaja competitiva y un crecimiento económico, también puede tener impactos negativos: por ejemplo, el uso recursos ya limitados, los daños ambientales, las desigualdades sociales e incluso una movilidad social disminuida. Al describir cómo se pueden diseñar y elegir las estrategias de innovación para contribuir de manera más efectiva a la creación de un mundo sostenible y cómo las acciones centradas en la sostenibilidad pueden ser una fuente de innovación, desarrolla una matriz de tres por cuatro que ofrece un marco para crear y analizar iniciativas e ideas centradas en la sostenibilidad. Coloca la innovación de producto, proceso y gestión en un eje y cuatro enfoques de sostenibilidad (reducción de costos y acciones enfocadas en la diferenciación para la sostenibilidad ambiental; acciones dirigidas por los empleados y la comunidad para la sostenibilidad social) en el otro.

El resultado es una serie de 12 estrategias de sostenibilidad que las empresas pueden usar como guías para lograr objetivos como la reducción de emisiones, menos desperdicio de material y mayor bienestar de los empleados y de la comunidad, entre otros.

Para ayudar en el cambio hacia la energía renovable, Claire Siegrist y Evangelos Katsamakas presentan los resultados de un proyecto de investigación de educación empresarial que analizó la cuestión de la generación de electricidad utilizando un sistema distribuido basado en energía renovable frente a uno centralizado basado en fósiles combustibles. Describen un sistema de apoyo a las decisiones que puede ayudar a los responsables políticos y las partes interesadas a evaluar la viabilidad de los sistemas de energía solar para los tejados. El sistema utiliza medidas basadas en modelos de evaluación regionales existentes y que incluyen información sobre variables como los costes para los consumidores, la demanda regional y el apoyo del gobierno. El documento muestra cómo calcular los costes y las cantidades de electricidad generada para ver cómo un sistema de energía renovable podría funcionar contra los combustibles fósiles tradicionales y cómo podría reducir las

emisiones en general. Por lo tanto, el uso del sistema de soporte puede llevar a acciones que ayudarán a reducir los costes y las emisiones, incluso si la generación distribuida no puede reemplazar completamente los sistemas centralizados hasta el momento.

Otra herramienta que es el resultado de un proyecto de educación empresarial proviene del trabajo de Karyl Leggio y el Coronel Reid Nichols. Los estudiantes usaron la simulación de Monte Carlo (una técnica que a menudo se usa para medir el riesgo) como un dispositivo de modelización financiera para apoyar las decisiones sobre cómo asignar recursos y justificar los costes relacionados con el Sistema de Boyas Interpretativas de la Bahía de Chesapeake, una red de boyas que proporciona a los usuarios la información técnica y científica necesaria para "mejorar los pronósticos marinos" y "monitorear la salud de la Bahía [de Chesapeake]." La herramienta resultante manejó la complejidad suficiente y tenía la sustancia suficiente para ser utilizada por la Administración Nacional Oceánica y Atmosférica (National Oceanic and Atmospheric Administration o NOAA) en su solicitud de presupuesto al Congreso. Se consideró particularmente útil para ayudar a la NOAA en su tarea de proteger y preservar la Bahía de Chesapeake, una importante fuente de mariscos y la base de un puerto importante en la costa este de los Estados Unidos.

El trabajo de Quan Le y Grace Jovanovic resalta la importancia de las colaboraciones para transformar vidas individuales y mover los sistemas comerciales hacia la obtención de resultados más sostenibles. Utilizando un modelo comercial en el que el café se compra directamente a los agricultores nicaragüenses a precios justos que respetan los precios mínimos previamente establecidos, el Café Ambiental, creado por los estudiantes, ofrece a sus productores de café estabilidad económica y estímulo. Esto, a su vez, permite a los agricultores hacer la transición a la agricultura orgánica al mismo tiempo que mejora la salud, la educación y el bienestar económico de sus familias. Los estudiantes y profesores que trabajan en esta colaboración con los agricultores, por otro lado, experimentan aspectos de transformación personal a través de negocios y lecciones de vida que son consistentes con el objetivo de solidaridad con los marginados.

Alain Decrop y Antje Graul, reconociendo las muchas formas en que el progreso en la economía compartida puede contribuir a un mundo más sostenible, abordan el desafío de mejorar la participación de los proveedores en dicha economía a través

de esquemas de consumo colaborativos que pueden generar menos desperdicio, reducción de nuevas compras, así como una mayor recirculación de productos. Su estudio presenta evidencia de que tanto la percepción reducida del riesgo como la mejor confianza en el sistema pueden mejorar la probabilidad de participación en una plataforma de intercambio. Los consumidores están más dispuestos a compartir sus activos como proveedores en lo que los autores denominan un acuerdo de "compensación recíproca (monetaria)" que en una configuración de "reciprocidad generalizada" porque perciben un mayor grado de riesgo con este último—no tienen garantía de "lo que están recibiendo a cambio" en la situación de reciprocidad generalizada. Los autores también muestran que estos esquemas de consumo colaborativo son más atractivos cuando un intermediario de mercado sin fines de lucro facilita el proceso de intercambio. Por lo tanto, es importante comprender estos aspectos de la economía del intercambio como tal y tomar medidas sobre ellos si la oferta de activos compartidos es crecer, satisfacer la creciente demanda de recursos compartidos y lograr las ventajas de hacerlo.

Ciertamente, como lo sugieren estos proyectos inspirados en la educación en management, es probable que haya muchos otros ejemplos en nuestras escuelas de negocios que puedan ayudarnos a crear un mundo más sostenible, floreciente y regenerador: ya sea porque nos ayuden a tomar decisiones a nivel de organización y de sistemas o porque nos inspiran a nivel personal.

POSDATA

Para aquellos de nosotros, por cierto, que estamos tentados a hacer el tipo de preguntas que hizo Hamming, notemos que concluyó su descripción de esos almuerzos de Bell Labs con la siguiente frase:

> "No fui bienvenido después de eso ¡Tuve que encontrar a alguien con quien comer!"

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RESÚMENES

Las estrategias de negocio para una innovación motivada por la sostenibilidad: Un marco conceptual

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La innovación ha sido y sigue siendo un factor clave en la ventaja competitiva de las empresas comerciales y el crecimiento económico de las naciones. Sin embargo, si bien la creación de nuevas ofertas que son atractivas para los clientes es fundamental para el éxito corporativo, los resultados económicos negativos sustanciales pueden acompañar a la búsqueda desenfrenada de la innovación. El presente trabajo investiga, entre otros, los daños medioambientales y la disminución de la estabilidad social y política como problemas que surgen de la innovación y presenta un marco que se puede usar para mejorar la sostenibilidad ambiental y social a través de la innovación. Atendiendo a los fines de este estudio, se clasifica la innovación en tres tipos: producto, proceso, gestión. Asimismo, hemos reducido las numerosas estrategias de sostenibilidad que han sido identificadas en las publicaciones en cuatro categorías: unas basadas en precio y diferenciación (ambiental) y otras orientadas al empleado y/o a la comunidad (social). Se presentan los tres tipos de innovación con las cuatro estrategias de sostenibilidad dando así doce enfoques para innovar teniendo en cuenta la sostenibilidad. Se proporcionan numerosos ejemplos para ilustrar cómo se está utilizando o se puede usar este marco. Estos criterios de sostenibilidad también podrían servir como motores de la innovación organizativa.

Palabras clave: innovación corporativa; tipos de innovación; estrategias ambientales; sostenibilidad social; estrategias de RSC; innovación sostenible

Un sistema de soporte de decisiones para la energía solar en el Bronx

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Este trabajo propone un sistema de soporte de decisiones para analizar la viabilidad económica y técnica de manejar la distribución de la energía solar fotovoltaica en el Bronx, Nueva York. Las investigaciones existentes muestran que la generación distribuida (GD) es una manera más eficaz de rediseñar el sistema de electricidad para integrar recursos más renovables en comparación con un sistema centralizado basado en combustibles fósiles. La viabilidad de descentralizar la producción de energía solar, sin embargo, depende de la ubicación y no tiene las economías de escala con las que cuentan los sistemas centralizados. Para determinar la viabilidad económica de la GD con la energía solar fotovoltaica a nivel regional, el sistema que se propone en este estudio incluye el precio relativo para los consumidores y el suministro de electricidad desde la red basado en un marco elaborado por el Laboratorio Nacional de Energía Renovable (*nombre oficial en inglés: National Renewable Energy Laboratory o NREL*). Las variables que se consideraron incluyen la demanda regional, la capacidad de espacio, los precios fijos y variables para los consumidores, los precios del suministro y los programas de apoyo gubernamental existentes. Así, usando los datos proporcionados por el gobierno de la ciudad de Nueva York y otras fuentes, se descubre en este trabajo que la energía solar en la azotea es económicamente viable a pesar de no poder satisfacer la demanda máxima del Bronx. Por lo tanto, se puede adoptar y usar el sistema propuesto por los decisiones públicos y privados en este y en otros lugares parecidos.

Palabras clave: energía solar; sistema de soporte de decisiones; inteligencia de negocios; viabilidad económica; viabilidad técnica; generación distribuida

El uso de la simulación de Monte Carlo como una herramienta de modelado financiero para apoyar los esfuerzos de sostenibilidad de una agencia gubernamental

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La Administración Nacional Oceánica y Atmosférica (nombre oficial en inglés: National Oceanic and Atmospheric Administration o NOAA) recopila datos de los ecosistemas para apoyar las actividades de conservación y el manejo de los recursos costeros mediante el estudio de factores de estrés que afectan a estuarios como la Bahía de Chesapeake, que es la más grande de los Estados Unidos. El presente trabajo procura ayudar a NOAA a justificar su existencia y su presupuesto utilizando la simulación de Monte Carlo como una herramienta de modelado financiero. Tales simulaciones proporcionan información sobre cómo distribuir los recursos identificados. Los resultados de este estudio generan un método innovador para ayudar a los gestores a decidir cuánto dinero gastar, en qué gastarlo y cómo adquirir recursos para el sistema de boyado interpretativo de la Bahía de Chesapeake. Además, este documento también demuestra cómo un proyecto experiencial en la educación de posgrado en negocios se puede usar para apoyar los esfuerzos de sostenibilidad al abordar los problemas centrados en la comunidad, al tiempo que mejora la conexión de los estudiantes entre la teoría y la aplicación.

Palabras clave: sostenibilidad del medio ambiente; simulación de Monte Carlo; modelado financiero; financiación gubernamental

De la crisis al café de especialidad: El caso de las cooperativas de pequeños agricultores y la educación empresarial jesuita para la sostenibilidad y la justicia

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Se ha demostrado que el aprendizaje-servicio (service-learning) basado en proyectos es una oportunidad de aprendizaje experiencial eficaz que complementa los planes de estudio estándar en las escuelas de negocios. La Universidad de Seattle (nombre oficial en inglés: Seattle University o SU) ha colaborado con su universidad hermana, la Universidad Centroamericana (UCA) en Managua (Nicaragua), desde 2015 en algunas experiencias de aprendizaje-servicio basado en proyectos enfocadas en prácticas sostenibles de cultivo de café y las implicaciones que el cambio climático puede tener en las granjas y comunidades de café. Esta colaboración con la UCA y las cooperativas de café tiene sus orígenes en la crisis mundial del café a principios de los 2000 y ha resultado en varios proyectos que apoyan a los cafetaleros que quieren entrar en el mercado de cafés de especialidad. Este trabajo presenta los resultados de nuestra investigación de campo anual en Peñas Blancas, Nicaragua en marzo de 2018. Basándose en el marco del café sostenible a la luz de los objetivos de sostenibilidad ambiental, social y económica, proporcionamos evidencia de que muchos agricultores en Nicaragua han estado experimentando problemas con la sostenibilidad de sus fincas. Además, nuestros resultados muestran que el modelo de comercio directo empleado por Café Ambiental, una empresa social dirigida por estudiantes de la SU, es el medio más eficaz para garantizar la sostenibilidad económica de los agricultores, permitiéndoles así desarrollar la sostenibilidad ambiental de sus fincas, así como mejorar la salud de la familia y la comunidad, la educación y el logro de medios en general para mejorar la sostenibilidad social. Este modelo de empresa social creado por estudiantes de la SU da pasos significativos para satisfacer las necesidades y mejorar las vidas de los cafetaleros en Nicaragua al mismo tiempo que preserva la tierra para que las generaciones futuras puedan cultivar café de calidad. Por último, creemos que nuestro proyecto tiene un potencial transferible a otras instituciones de educación superior jesuitas que utilizan y persiguen estructuras y objetivos similares.

Palabras clave: café sostenible; cooperativas; educación empresarial jesuita; Universidad de Seattle; Universidad Centroamericana; Nicaragua

El papel de la confianza en el sistema y la percepción del riesgo en proporcionar activos para los esquemas de consumo colaborativo

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El surgimiento de la economía compartida ha estimulado el desarrollo de esquemas de consumo colaborativo (CC) en el mundo. La promesa de "no propiedad" en la red entre pares en particular, hace que sea atractivo para una gran cantidad de usuarios participar en prácticas como el "carshare" (movilidad compartida) y el alquiler de alojamientos privados o el suministro de herramientas por parte de sus compañeros. Sin embargo, si bien existen beneficios financieros y ambientales tanto para los usuarios como para los proveedores, los proveedores de bienes privados pueden ser reacios en muchos casos a ofrecer sus pertenencias para compartir. El presente trabajo se basa en la teoría de intercambio social para examinar el papel fundamental de la reciprocidad generalizada, equilibrada de trueque y dinero como característica de esquema fundamental que predice la intención de los proveedores de participar en esquemas de CC en la red entre pares. Así, los hallazgos de dos estudios empíricos proporcionan evidencia de que los consumidores están más dispuestos a proporcionar sus activos personales para una compensación recíproca donde el riesgo percibido funciona como mediador del efecto explicado. Asimismo, se usa la mediación de mercado para mostrar que los esquemas CC son más atractivos para los consumidores cuando se les facilita un intermediario de mercado "sin fines de lucro" (en comparación con uno que tiene fines de lucro), haciéndo hincapié en la inclinación de los consumidores a salirse del mercado mientras comparten. Por lo tanto, se propone un mecanismo en el que la confianza en el sistema media las relaciones propuestas.

Palabras clave: economía compartida; consumo colaborativo; confianza; reciprocidad

The journal welcomes submissions from all management disciplines (e.g., international business, accounting, marketing, finance, operations) and related fields (e.g., economics, political science) as long as the manuscript contributes to our academic understanding of the role of management in achieving global sustainability. These articles shall be subject to a double-blind review process overseen by the editorial board. Submissions of theoretical work, empirical studies, book reviews, and practitioner manuscripts in either Spanish or English are all encouraged, with research briefs and book reviews not exceeding 1500 words and full research papers not exceeding 7000 words.

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