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20th Anniversary Invited Article

Sustainable Operations Management Through the Perspective of *Manufacturing & Service Operations Management*

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Abstract. We review the sustainable operations management research published in the first 20 years of *Manufacturing & Service Operations Management* (M&SOM), and we outline our hopes for the next 20 years. This review provides a “big picture” overview of trends in the sustainable operations management research in M&SOM, along with an impact assessment both inside and outside the boundaries of operations management research. We provide a brief chronological survey of sustainable operations management publications in M&SOM, as well as a high-level citation analysis. Together, these analyses indicate that the topics studied in the sustainable operations management publications in M&SOM have largely followed some issues of business relevance and have made a substantial scholarly impact both inside and outside our field. We also propose a number of open research directions.

History: This paper has been accepted for the *Manufacturing & Service Operations Management* 20th Anniversary Special Issue.

Keywords: sustainability • environment • public policy • operations management

1. Introduction

This paper is one of about 20 commissioned by the editor-in-chief of *Manufacturing & Service Operations Management* (M&SOM) in connection with the 20th anniversary of the journal. The objective of this paper is to review sustainable operations management research published in M&SOM to date, identify trends, highlight the contributions of this research, and discuss how the MSOM community can further contribute to more sustainable business. To this end, we first identify 52 papers that have been published in M&SOM between 2003 and 2018 within the scope of sustainable (i.e., environmentally and socially responsible) operations management research. We then categorize these papers with respect to research topics and analyze the chronological evolution of these topics. We conduct a citation analysis to determine where these distinct streams had the most influence—that is, how frequently these papers are cited in operations management (OM) journals versus in journals in other disciplines. This citation analysis helps us identify opportunities for sustainable operations management research to have a broader impact.

The selection of these 52 papers, their categorization by topic, and the classification of the domains

citing them are all rather subjective. Nevertheless, this approach serves as a means to a subjective trend and impact assessment, and we hope that they will provide guidance for even more impactful research in the near future. Because this paper was commissioned as part of the 20th Anniversary Special Issue of M&SOM, it is narrowly focused on sustainable OM research as seen through the perspective of this journal. The field of sustainable OM is, of course, much broader and older than this journal. For good overviews of sustainable OM, see, for instance, Angell and Klassen (1999), Kleindorfer et al. (2005), and Corbett and Klassen (2006). For overviews of sustainable supply chain management more specifically, see, for instance, Seuring and Müller (2008), Atasu (2016), and Bouchery et al. (2017).

2. What Has Been Published in M&SOM on Sustainable OM?

The objective of this section is to analyze the contributions of the M&SOM journal to sustainable operations management research. To this end, we first survey all publications that appeared in M&SOM between 1998 and 2018, and we identify 52 papers that we consider related to sustainable operations

management research. Through a purely subjective assessment,¹ we cluster these papers into five major streams (Table A.1): *closed-loop supply chains* (CLSC), *low-carbon economy* (LCE), *environmental management and performance* (EMP), *innovation* (INN), and *social responsibility* (SR). We summarize the major issues covered in each of these streams. We then provide a visualization of the trajectory of this research in terms of the volume and evolution of each stream. We recognize that several papers could be classified into multiple streams, but our ultimate goal is to draw broader conclusions about the overall body of research rather than develop detailed prescriptions related to specific streams.

Research on closed-loop supply chains began in the 1990s; see the early reviews and books by Fleischmann et al. (1997) and Guide and Van Wassenhove (2001, 2003). This CLSC research lays the theoretical foundation for much of the recent discussion on the circular economy (Agrawal et al. 2019). The scope of CLSC research published in M&SOM consists of a number of broad themes. The first is *management of consumer returns*—for example, how consumer return decisions can be affected by sales effort (Ferguson et al. 2006) or return processes (Shulman et al. 2009). The second theme is *remanufacturing*—for example, determining the optimal strategy for marketing remanufactured products (Guide et al. 2003, Ray et al. 2005), discovering the factors that influence the profitability of remanufacturing (Subramanian and Subramanyam 2012, Zhang and Zhang 2018), and methods for coordinating remanufacturing with other operational activities, such as the sale of new products, the fulfillment of warranty needs, and safe waste disposal (Zhou et al. 2011, Pinçe et al. 2016, Calmon and Graves 2017). The third and last theme is *recycling*—for example, methods for recycling systems for improved operational and environmental efficiency (Demeester et al. 2004, Demeester et al. 2013).

The low-carbon economy research published in M&SOM studies energy, emissions, and climate change. This domain covers three topics. The first is the study of the effects and design of *carbon emission regulation*, including ways in which regulatory and information-based instruments (e.g., carbon tax, carbon cap-and-trade systems, carbon footprint reporting, and accounting mechanisms) influence producers' production decisions and carbon-reduction efforts (Caro et al. 2013, Jira and Toffel 2013, Sunar and Plambeck 2016) or firms' overall market performance (Kroes et al. 2012). The second topic is the adoption of *energy-efficient or clean production technologies*—for example, how adoption can be incentivized by regulation (Plambeck and Taylor 2013, Drake 2018) or impacted by market forces (Wang et al. 2013). The third topic is the analysis of *renewable energy strategies*—for example, how the

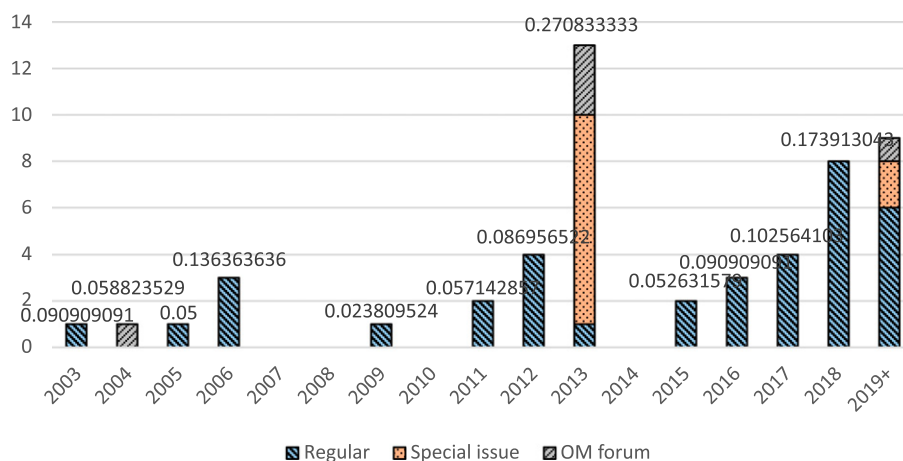
investment and marketing decisions between renewable and traditional energy sources should be coordinated (Wu and Kapuscinski 2013, Hu et al. 2015, Aflaki and Netessine 2017, Al-Gwaiz et al. 2016).

Under the broad umbrella of environmental management and performance studies published in M&SOM, we find studies that address environmental-resource allocation (Dawande et al. 2013), pollution control (Drake and Spinler 2013), environmental management practices (Corbett and Klassen 2006, Muthulingam et al. 2013) and standards (e.g., International Organization for Standardization [ISO] 14000 as in Corbett 2006), information-related instruments (e.g., eco-labels as in Murali et al. 2019 and information dissemination about hazardous chemicals as in Fu et al. 2019), supply chain activities (e.g., inspections as in Lo et al. 2018), and market valuation of environmental efforts (e.g., stock market reactions as in Mani and Muthulingam 2019).

Under the innovation category, papers published in M&SOM examine four different subjects. The first is *process improvement*—for example, process alterations to turn waste into useful by-products (Lee 2012). Next is the development and adoption of *advanced technologies* such as cleantech (Plambeck 2013) and electric vehicles (Lim et al. 2015). The third subject is *creative designs* of products or services—for example, providing a cheaper and healthier source of lighting (Uppari et al. 2019), planning for a waste-to-energy firm (Ata et al. 2012), and using modularity in product designs (Agrawal and Ülkü 2012). Finally, the fourth subject is *sustainable business model innovation* (Girotra and Netessine 2013), such as crowdsourcing in logistics service offerings (Qi et al. 2018), as well as servicizing and sharing economy models (Bellos et al. 2017, Agrawal et al. 2019, Örsdemir et al. 2019).

Finally, research related to social responsibility published in M&SOM touches upon a wide range of topics. One example is *responsible sourcing*—for example, supplier selection (Liu et al. 2019), incentive mechanisms adopted by buyers (Plambeck and Taylor 2016, Caro et al. 2018), and how social responsibility practices impact consumer valuations (Kraft et al. 2018). These topics also include *agricultural operations* (de Zegher et al. 2019, Liao et al. 2019), *serving underserved populations* (Chu et al. 2018, Yu et al. 2018), and enhancing the effectiveness of *nongovernmental organizations and nonprofit organizations* (Privett and Erhun 2011, Kraft et al. 2013).

Having outlined these five broad categories, we can now examine how they have evolved. The total publication counts in Figure 1 show that M&SOM has published, on average, about three sustainable operations management papers per year, with a clear and increasing trend: the majority of these publications appeared in the last six years, boosted in part

Figure 1. (Color online) *Manufacturing & Service Operations Management* Sustainable Operations Publications by Paper Type

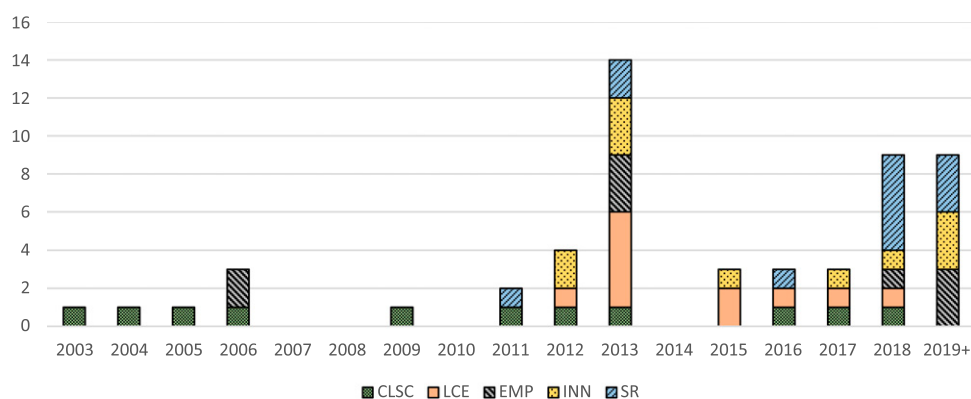
Notes. OM forum papers are counted separately regardless of the type of issue they appear in. The data labels on each bar tabulate the number of sustainable operations publications as a percentage of all papers in M&SOM in that year. All Articles in Advance that are not yet in print are counted as 2019+ papers.

by two special issues (Plambeck and Toktay 2013, Lee 2019).

In their review article, Corbett and Klassen (2006, p. 19) offer several conjectures, including (conjecture 2) that “[e]nvironmental management in operations will have become an established and accepted part of mainstream OM by 2015.” Looking through the lens of publications in M&SOM, it is debatable whether that conjecture held in 2015, but in 2018, it seems indisputable that sustainable OM reached that threshold, because it accounts for 17% of all papers published in M&SOM in that year. The Corbett and Klassen (2006, p. 19) review focused on environmental issues, but it also included the comment that “[a]ll three conjectures made here could also apply to social issues or sustainability. The current state of research in OM with a social perspective is too limited to support that, but we hope that will change soon.” The fact that this 20th Anniversary Special Issue

includes a separate contribution on social responsibility (Plambeck and Ramdas 2019) suggests that work on social issues in OM is also becoming a mainstream research area.

Figure 2 shows the breakdown of the same set of papers by the research streams defined in Table A.1. CLSC research constitutes the majority of the early sustainable operations management publications in M&SOM, and it has been a consistent presence. Work on EMP came soon after, followed by LCE, INN, and SR research, respectively. The CLSC stream’s lead can likely be attributed to the original workshop series initiated by the RevLog and CLSC working groups from Rotterdam School of Management at Erasmus University that started in 1998 and from INSEAD in 2001, as well as the two influential books these networks have produced (Guide and Van Wassenhove 2003, Dekker et al. 2004). We also conjecture that other influences include the European perspectives, driven

Figure 2. (Color online) *Manufacturing & Service Operations Management* Sustainable Operations Publication Counts in the Closed-Loop Supply Chain (CLSC), Low-Carbon Economy (LCE), Environmental Management and Performance (EMP), Innovation (INN), and Social Responsibility (SR) Categories

by German and Dutch recycling laws and Robert Lund's influential work (Lund 1996) on remanufacturing in the United States. CLSC was not necessarily the earliest focus of research in sustainable OM more broadly, but it appears to have been the first area in which the questions and methods used were sufficiently familiar to the MSOM community to gain acceptance in its journal.

Research in sustainable OM already included substantial activity in EMP during the 1990s, as witnessed by the three special issues published in *Production and Operations Management* in 2001 (Corbett and Kleindorfer 2001a, b) and 2003 (Corbett and Kleindorfer 2003). Much (but not all) of that work was based on empirical methods that were, at that time, not as commonly used in M&SOM. The increased presence of this stream of work in M&SOM is likely due to both an increasing sophistication of the methods used in this research and an increasing appreciation within the MSOM community of these methods, in addition to an increased recognition of the importance of the questions being studied. This stream largely follows the regulations or standards arising and diffusing around the world such as energy-efficiency standards, eco-labels, ISO 14000, and the Waste Electrical and Electronic Equipment, End-of-Life Vehicles, and Registration, Evaluation, Authorisation and Restriction of Chemicals directives of the European Commission.

Not surprisingly, the interest in research on LCE in M&SOM reflects the growing awareness of the challenges of global climate change and its business implications. The *M&SOM Special Issue on the Environment* (Plambeck and Toktay 2013) contains several papers on this topic, and at least one paper in this area has been published every year since 2015. The importance of innovation, both in business models (e.g., the sharing economy) and in products (e.g., cleantech) is widely recognized as an important vehicle for a sustainable future, as evidenced by the amount of investment and entrepreneurial activity in these areas. The M&SOM research on innovation follows these trends and is balanced in its coverage of business model and product innovation. Intriguingly, although scholarly interest in the social responsibility of business began decades, if not centuries, ago, published research in M&SOM appears to be concentrated in the last three years. This foreshadows an increasing interest in social sustainability. This is aligned with the growing recognition in business practice that sustainability is not just about the environment; it also encompasses social-impact considerations.

It is encouraging to see the growth over time in sustainable operations management research appearing in M&SOM. It is also encouraging to see the broadening of its focus. Although CLSC is a critical component

of sustainability, it is also closest to the historical focus of many scholars in the MSOM community. The more recent focus on LCE, EMP, INN, and SR suggests that sustainable OM research in M&SOM seeks to address a wider range of societal challenges.

3. What Is the Impact of Sustainable Operations Research Published in M&SOM?

In the previous section, we outlined five main streams of research within the set of sustainable OM papers published in M&SOM. In this section, we analyze where the impact of these publication streams has been observed. To do so, we perform a citation analysis using the Web of Science Database.² Specifically, the Web of Science Database assigns academic journals into field clusters, and it provides a distribution of citations according to these field clusters. For example, Figure 3 shows how the citations to Guide et al. (2003) are distributed across clusters. We conduct this analysis on the 52 articles we identified, and we find that these 52 articles are cited in 69 distinct fields.

We subjectively categorize these Web of Science Database fields into five aggregate areas: OM/OR, business-non-OM/OR (excluding operations management journal publications), economics, environmental research, and science and engineering³ (Table A.2). The 11 fields that do not fit in any of these aggregate areas are listed in the "Other" category and are not considered in the analysis below. We find that these 52 papers were cited 2,789 times (data collected on January 15, 2019; full citation data are available from the authors). Five papers had more than 200 citations each, representing 57% of the total.

Figures 4, 5, and 6 show the citations to M&SOM sustainable operations management publications. They yield a few key observations. First, Figure 4 shows, not surprisingly, that the CLSC stream has the highest number of citations, which can be attributed to its earlier presence and the size of the community working on this topic in both the United States and Europe. The EMP stream has the second highest count, which is consistent with our earlier note that the EMP stream was already well established in the field, with authors publishing work in other OM journals. The subdomains that emerged later (LCE, INN, and SR) have relatively lower citation counts, as expected given their relative recency. What is perhaps most interesting (Figure 5) is the substantial number of citations to sustainable operations management research by other areas (with the exception of economics). In fact, the citations received from economics, environmental research, and science and engineering journals constitute about 45% of total citations. This is a pleasant surprise for the sustainable

Figure 3. (Color online) Citation Analysis of Guide et al. (2003) Using the Web of Science Database, with Numbers of Citations Counted According to Research Field Clusters



OM research community, because these high citation numbers highlight the interdisciplinary visibility of sustainable OM research published in *M&SOM*. Figure 6 investigates the citation profile of the five sustainable OM research streams and suggests that different sustainable OM research streams have developed slightly different audiences. CLSC work has been most cited by OM/OR and science/engineering publications, whereas the environmental management and performance and innovation research streams received their largest citation counts from non-OM business and from environmental research journals.

The largest proportion of citations received from economics journals appeared in the innovation category (though still a small percentage). Citations to the low-carbon economy research published in *M&SOM* mainly came from OM/OR outlets, non-OM business, and environmental research outlets. Finally, citations to the social responsibility category mainly came from non-OM business research as well as OM/OR outlets. Overall, the exact distinctions are not what matters, but these observations suggest that the sustainable OM research published in *M&SOM* has received substantial interest from other disciplines in

Figure 4. (Color online) *Manufacturing & Service Operations Management* Sustainable Operations Citation Counts in the Closed-Loop Supply Chain (CLSC), Low-Carbon Economy (LCE), Environmental Management and Performance (EMP), Innovation (INN), and Social Responsibility (SR) Categories

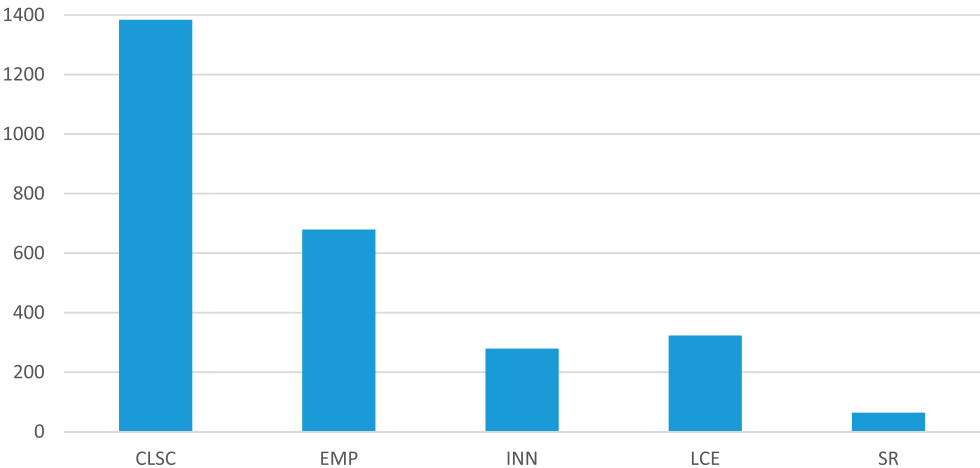
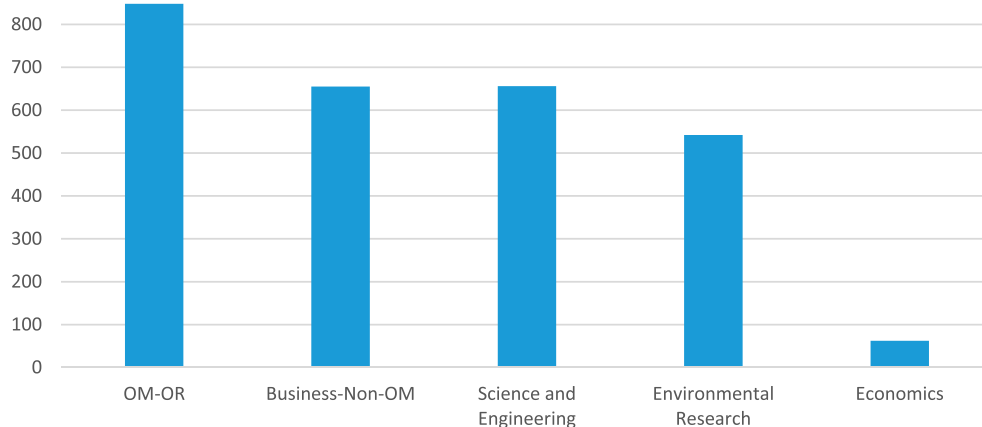


Figure 5. (Color online) *Manufacturing & Service Operations Management* Sustainable Operations Citation Counts by Citing Field



science, engineering, and environmental research. However, we should add the caveat that the majority of these citations are due to a small set of four early publications on CLSC and one early review paper in EMP.

4. Sustainable Operations Research in M&SOM at the 40-Year Mark

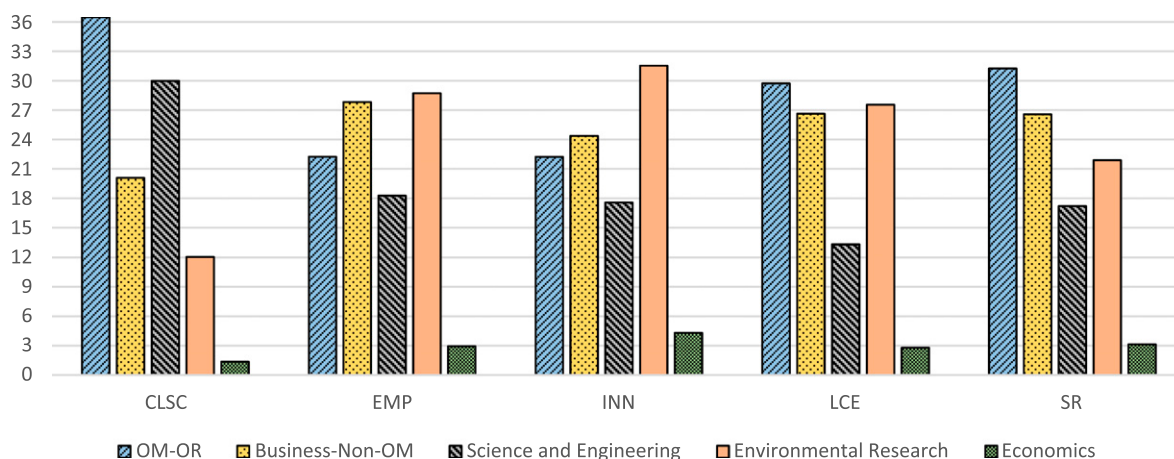
The evolution of sustainable OM research and its citation profile suggest a healthy growth in the field. It is a good sign that sustainable OM publications in *M&SOM* receive substantial visibility from other disciplines. It is our hope and expectation that this growth and impact profile will only strengthen in the near future. Looking ahead another 20 years, we share some thoughts—part forecast and part wish list—of

what will have happened in sustainable operations by the 40-year anniversary of the journal.

The Low-Carbon Economy Stream Will Have Significantly Expanded and Overlapped with the Innovation Stream

Climate change is a daunting global challenge that demands the engagement of the business community in both adaptation and mitigation. *Adaptation* for companies involves adjusting how they manage their supply chains, site their facilities, adjust their mix of products and services, and measure and report on their impacts in light of physical risks and regulatory changes related to climate change. *Mitigation* engages the innovation pathway and involves developing new products, technologies, and services that support

Figure 6. (Color online) *Manufacturing & Service Operations Management* Sustainable OM Citation Percentages in the Closed-Loop Supply Chain (CLSC), Low-Carbon Economy (LCE), Environmental Management and Performance (EMP), Innovation (INN), and Social Responsibility (SR) Categories



Notes. Each bar indicates citations to papers in that category that originate from journals in the area in question as a percentage of total citations to papers in that category. For instance, 12% of all citations to CLSC papers in *M&SOM* come from papers in the “environmental research” area.

the transition to a low-carbon economy. M&SOM has already published research on the business implications of carbon reporting and regulation (Kroes et al. 2012, Caro et al. 2013, Jira and Toffel 2013, Sunar and Plambeck 2016, Drake 2018), the operations of renewable energy sources (Wu and Kapuscinski 2013, Hu et al. 2015, Aflaki and Netessine 2017, Al-Gwaiz et al. 2016), and new products/technologies such as electric vehicles and waste-to-energy plants (Ata et al. 2012, Lee 2012, Lim et al. 2015). However, there are still many open questions in these areas that we hope to see addressed in more depth and with a practical impact over the next two decades. We also hope to see more intersectionality between the innovation and product-development research community and the sustainable operations research community.

The Social Responsibility Stream Will Have Significantly Expanded

Climate change has disproportionate implications for the most vulnerable populations through such pathways as food insecurity, health impacts, and population displacement. Even more basically, access to clean, reliable energy is not guaranteed for large segments of the population in some emerging economies. More generally, in such areas as agriculture or fishing, the “far end” of the supply chain includes a large number of small-scale contributors living in poverty and using subsistence practices that collectively impose harm on the environment. With a few exceptions, sustainable operations management research in M&SOM has not considered the intertwined nature of environmental and social sustainability, nor studied business strategies that seek to be inclusive of underserved populations; rather, the attention has been more narrowly focused on strategies such as visibility and auditing to improve labor and other related challenges in supply chains (Plambeck and Taylor 2016, Caro et al. 2018, Liu et al. 2019).

Motivated by the environmental-justice literature (which focuses on the equitable treatment of underserved populations) and the emerging concept of “just sustainability,” Kalkanici et al. (2019) elaborate on the concept of “inclusive innovation” and develop propositions about how inclusive innovation can be practiced in product/service innovation, process/business model innovation, and supply chain innovation to improve social sustainability. de Zegher et al. (2019), Liao et al. (2019), and Uppari et al. (2019) are recent M&SOM publications in this vein. They explicitly focus on supply chain and product innovations that benefit underserved populations. We hope this is only the start of a much deeper examination of these issues in global supply chains, with an emphasis on the social impacts of climate change and

rapid urbanization, two of the most salient issues affecting underserved urban and rural communities.

Emerging Technologies Will Open New Research Areas

Many exciting technological developments, often associated with the “digital revolution,” promise to transform the ways in which businesses source and manufacture and transform the ways in which people live, transact, and work, including—but not limited to—blockchains, additive manufacturing, the Internet of things, autonomy, and artificial intelligence. Each of these areas has profound implications for environmental—and especially social—dimensions of sustainability. If it unfolds optimally, the digital revolution can be a force for equitable, sustainable development; if not, it can exacerbate inequities at both local and global scales (e.g., reinforce the digital divide or hardcode bias into algorithms). Investigating service design, operations strategy, and supply chain management questions that relate to the sustainable deployment of these technologies is a rich area for research. Supply chain traceability, large-scale sensor-based measurements, and other data availability will also allow OM researchers to ask novel research questions about social impact, such as the human-trafficking implications of supply chain practices (Bastani and de Zegher 2019).

The “smart-city” concept is a technology-driven, data-rich area of research that has attracted scholarly activity in fields ranging from engineering to computing to urban planning. The smart-city concept involves collecting data from a wide range of sensors, so that cities can utilize their assets and resources more efficiently. Emerging OM research in this area focuses mainly on variations of traditional themes, such as congestion management or retail service optimization. Thinking more broadly, however, smart-city technologies can engage citizens in data collection and participatory decision making, and these technologies can be deployed to create not only smart cities, but also more livable and more sustainable communities. This research holds the potential for interdisciplinary work with nonbusiness faculty. It could also engage other business disciplines or subdisciplines within OM. For example, although a few studies touch upon behavioral issues in the context of socially responsible business, sustainable operations research could benefit from a deeper understanding of consumer, employee, or managerial behavior to better identify operational mechanisms that improve social and environmental responsibility.

Interdisciplinary Research Will Have Become More Prominent

Corbett and Klassen (2006, p. 19) conjectured that “environmental issues will force more interdisciplinary

research in OM. As a result, a significantly higher proportion of research papers focusing on OM and environmental issues will be coauthored with scholars in other disciplines, including economics, political science, and engineering.” Approximately 10% of the M&SOM sustainable operations papers we reviewed already include a non-OM academic coauthor from marketing, behavioral decision making, or engineering; one included a practicing biochemist. The extent to which sustainable OM research published in M&SOM (and other journals) is already recognized by scholars in other disciplines forms a strong foundation for interdisciplinary research and reciprocal learning, and there are a wealth of other opportunities in the emerging areas discussed above, as well as others not covered here.

Blass and Corbett (2018) point to a variety of ways in which the life-cycle assessment field could benefit from a stronger OM perspective, and vice versa. Similarly, Atasu (2019) discusses how a sustainable OM perspective can support industrial ecology research by identifying different approaches to conceptualize the economics of regulated recycling systems. The recent *Nature* article by Turcheniuk et al. (2018) on the limited supply of rare metals used in electric vehicles is an example of collaboration between scholars in OM and materials science. Ongoing work on integrating more structured decision-making methods into chemical-alternatives analysis (Malloy et al. 2016) combines OM with law, public health, chemistry, environmental engineering, and more. However, our impression is that this integration has not yet become widespread in sustainable OM. For example, this is quite different from healthcare operations, in which coauthorship with physicians, scholars in medicine, and scholars in public health seems more common. The recent emphasis in M&SOM on practice-based research could be a good vehicle to advance academic and nonacademic collaborations in other disciplines.

Our Impact in Other Fields Will Have Grown

Even though the citation analysis in Section 3 demonstrates that work on sustainable OM published in M&SOM has an impact in other fields, we believe more can be done. One option for expanding this impact is to invest in interdisciplinary collaborations, as discussed above. Another is to use environmental- and social-impact measurement approaches that are more universal in nature. Much of the research on sustainable OM seeks—explicitly or implicitly, and directly or indirectly—to make improvements in some environmental and social phenomena, whether it be climate change, circular economy, or human rights. Each of these phenomena are associated with (often multiple) academic disciplines that study them, whether from the perspective of atmospheric science,

environmental science, economics, toxicology, law, policy, or sociology. Each of these disciplines has its own language and measurement framework. We believe that adopting the same approach to measurement as these other fields is a necessary condition for research in sustainable OM to gain more traction in these target disciplines. There are certainly some publications and scholars in the OM community that do this, but it is not a widespread practice.

This ongoing challenge is illustrated by the outcome of a proposed special issue in *Production and Operations Management* in 2009. The subject of this issue was “Measuring the Impact of Sustainable Operations” (with a call for papers issued in 2009), which attracted markedly fewer submissions than hoped for, indicating that the special issue may have been ahead of its time. Of course, this is a two-way street: A special issue of the *Journal of Industrial Ecology* that sought a comparable connection from the industrial ecology side also received fewer submissions than hoped for, and the guest editors speculated that this lack of interest was partly due to a lack of attention to business issues in the field of industrial ecology in general, as well as a lack of attention to industrial ecology in the business literature (Hoffman et al. 2014; see Blass and Corbett (2018) and Atasu (2019) for related discussions). Our community can perhaps be proactive about overcoming these barriers by developing widely accepted impact-measurement metrics, organizing special issues and awards that promote cross-fertilization with other disciplines, and commissioning interdisciplinary perspective pieces.

5. Closing Thoughts

This article was commissioned as part of a special issue to commemorate the 20th anniversary of M&SOM; hence, our viewpoint was centered on M&SOM. Of course, M&SOM is not the only journal that captures contributions in sustainable operations. Much excellent work on sustainable operations has appeared in other journals as well, and some of this work dates back to before the existence of M&SOM, so our observations drawing on the analysis of publications and citations in this journal do not fully apply to the field of sustainable OM in general. Nevertheless, under the heading of what we would like to see at the time of the M&SOM’s 40th anniversary, we hope that some of our broader suggestions do apply to the broader sustainable OM community.

We believe that M&SOM can continue to support the growth and impact of environmental and social sustainability research in a number of ways, including special issues, new publication formats, research awards, and facilitated outreach to other disciplines. Research awards such as the new Responsible Research in OM Award of the Manufacturing and Service Operations

Management Society, whose underlying principles involve multidisciplinary and impactful research, will help move our society in this direction. Special issues commissioned since 2017 include those on smart-city operations; people-centric operations; the sharing economy and innovative marketplaces; responsible operations and supply chain management; and responsible research in operations management. Such research awards and special issues can lead to opportunities for intersectional research that studies sustainability from new angles and that has an impact beyond our own discipline.

We close by noting that, as society in general and business students in particular become more interested in environmental and social issues, their attention will inevitably be drawn to firms' operations. As the OM community, we have an opportunity to do research that many others are excited about, if we choose to work on the right problems and conduct this research in a way that broader audiences care about and understand. Other traditional research areas within OM (e.g., inventory management, supply chains, revenue management, and capacity planning) are also very important, but they may be less likely to excite non-OM audiences to the same degree. Helping to prevent the

next Rana Plaza disaster or helping to make farmers better off while avoiding deforestation may have much broader appeal and may catalyze broader interest in the relevance and impact of the operations management discipline.

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Appendix

Table A.1. Sustainable Operations Management Articles Published in *Manufacturing & Service Operations Management* Between 1998 and 2018

Category	Articles
Closed-loop supply chain	Guide et al. (2003), Demeester et al. (2004), Ray et al. (2005), Ferguson et al. (2006), Shulman et al. (2009), Zhou et al. (2011), Subramanian and Subramanyam (2012), Demeester et al. (2013), Pinçe et al. (2016), Calmon and Graves (2017), Zhang and Zhang (2018)
Low-carbon economy	Kroes et al. (2012), Plambeck and Taylor (2013), Wang et al. (2013), Caro et al. (2013), Jira and Toffel (2013), Wu and Kapuscinski (2013), Hu et al. (2015), Al-Gwaiz et al. (2016), Sunar and Plambeck (2016), Aflaki and Netessine (2017), Drake (2018)
Environmental management and performance	Corbett (2006), Corbett and Klassen (2006), Dawande et al. (2013), Drake and Spinler (2013), Muthulingam et al. (2013), Mani and Muthulingam (2019), Lo et al. (2018), Fu et al. (2019), Murali et al. (2019)
Innovation	Lee (2012), Ata et al. (2012), Agrawal and Ülkü (2012), Girotra and Netessine (2013), Plambeck (2013), Lim et al. (2015), Bellos et al. (2017), Agrawal et al. (2019), Örsdemir et al. (2019), Qi et al. (2018)
Social responsibility	Privett and Erhun (2011), Kraft et al. (2013), Plambeck and Taylor (2016), Yu et al. (2018), Chu et al. (2018), Kraft et al. (2018), Caro et al. (2018), de Zegher et al. (2019), Liao et al. (2019), Liu et al. (2019), Uppari et al. (2019)

Table A.2. Web of Science Citation Analysis Fields and Aggregation

Aggregate field	Subfield (citations)
Business (non-OM)	Business (143), business finance (12), ethics (9), law (1), management (485), psychology applied (2), social issues (3)
Economics	Agricultural economics policy (1), agronomy (2), economics (53), health policy services (1), planning development (3), public administration (1), urban studies (1)
Environmental research	Energy fuels (15), engineering environmental (120), environmental sciences (176), environmental studies (82), green sustainable science technology (160), public environmental occupational health (2), water resources (2)
OM/OR	Engineering industrial (247), operations research management science (601)
Other	Area studies (1), communication (3), education educational research (3), emergency medicine (1), hospitality leisure sport tourism (2), logic (1)
Science/engineering	Automation control systems (30), biotechnology applied microbiology (2), computer science artificial intelligence (14), computer science cybernetics (9), computer science hardware architecture (3), computer science information systems (25), computer science interdisciplinary applications (35), computer science software engineering (6), computer science theory methods (26), construction building technology (1), engineering biomedical (1), engineering chemical (2), engineering civil (20), engineering electrical electronic (26), engineering manufacturing (267), engineering mechanical (21), engineering multidisciplinary (28), food science technology (2), geography (1), geoscience multidisciplinary (2), healthcare sciences services (1), information science library science (6), materials science multidisciplinary (7), materials science textiles (1), mathematics (2), mathematics applied (6), mathematics interdisciplinary applications (23), mechanics (5), meteorology atmospheric science (4), multidisciplinary sciences (7), nanoscience nanotechnology (1), robotics (4), social sciences interdisciplinary (1), social sciences mathematical methods (5), sociology (1), social work (1), telecommunications (4), thermodynamics (3), transportation (27), transportation science technology (26)

Endnotes

¹ This classification is neither mutually exclusive nor absolute, but this broad-strokes approach helps us make some equally broad-strokes observations about the past and future of sustainable OM research in M&SOM.

² Certain data and graphics included herein are derived from Clarivate Analytics Web of Science Core Collection. © Copyright Clarivate Analytics 2019. All rights reserved.

³ For example, the *Journal of Industrial Ecology* and the *Journal of Cleaner Production* fall into the “engineering industrial,” “environmental sciences,” and “green sustainable science technology” clusters, which are then categorized as *environmental research*. For another example, the *Journal of Environmental Economics and Management* belongs to the “business” category (later classified under the *business-non-OM/OR* category), the “economics” category (under *economics*), and “environmental studies” (under *environmental research*).

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