Green Technologies and Sustainability 2 (2024) 100110

Contents lists available at ScienceDirect

Green Technologies and Sustainability

journal homepage:
https://www.keaipublishing.com/en/journals/green-technologies-and-sustainability/

Full-length article

Conceptualization and theorizing process of innovation metrics for green business practices

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ARTICLE INFO

Keywords:
Environment metrics
Green business
Innovation metrics
Measurement
Social metrics

ABSTRACT

This research explores the wide range of measurement techniques used to evaluate innovation in businesses. We suggest a potential method for developing theories by combining the collective knowledge of academics and practitioners with a synthesis of prior empirical findings. There are differences in opinion among experts and scholars regarding innovation measurement in the discourse. While some argue that analyzing the mechanisms promoting innovation is important, others stress the significance of analyzing its results. The discussion also touches on how much companies should develop their capacity for innovation in order to remain competitive in the marketplace. The usefulness and validity of different metrics and tools for measuring innovation remain controversial despite decades of research, with conflicting findings frequently appearing in published literature. We argue that innovation is a continuous process, as demonstrated by the results of applied research and development (R&D), which are informed by engineering practices, theoretical understandings, end-user needs, sustainability, and environmental impact. This study adds to the current conversation by putting forth a nuanced viewpoint that recognizes the complexity of innovation and pushes for an all-encompassing method of measurement.

1. Introduction

According to Peter Drucker "you can't manage what you don't measure" [1]. Innovation is the introduction of a new or significantly improved process, product (goods and service), or a new marketing/organizational method in business practices [2]. In nutshell, it is the adoption of any innovative idea or practice that led to technological advancements, improvement of processes and transformation of our behavior to ensure eco-friendly systems and better cost-effectiveness in the operations and outcomes [3]. But for many businesses, assessing, evaluating, and benchmarking innovation skill and practice has remained an important but challenging challenge [4,5]. Measuring the intricate processes that could affect any organization's capacity for innovation is crucial for assuring optimal management in this situation [6]. The contradictory views by different scholars have further made the debate critical between use of experience and wisdom versus scientifically designed tools and metrics to measure innovation [7]. Although some contend that measuring aids in the audit of structural antecedents, procedures, and results, others contend that measurement deters managers from taking risks in order to explore more innovative ground-breaking ideas [8]. Evidence suggests that innovation measurement impedes and even prevents innovation since it puts pressure on the contributors to focus more on narrow objectives than a broader vision [9–11].

The purpose of this paper is not to evaluate either the merits of measurement metrics or their intriguing role in inhibiting innovation efforts. But it aims to explore possibilities to conceptualize theoretical models to guide green business practices by drawing inputs from empirical literature and authors' wisdom for further testing and validation. In addition, it intends to review whether the social innovation metrics can be aligned with business process innovation so that sustainability issues associated with the quality of life and environment are adequately addressed [12]. There is hardly any perfect means to fulfill such requirements and hence we cannot rule out the importance and

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https://doi.org/10.1016/j.grets.2024.100110
Received 9 September 2023; Received in revised form 25 March 2024; Accepted 9 July 2024
Available online 14 July 2024

relevance of certain informal components that may aptly correlate with cultural diversity to ensure sustainability practices in a multi-cultural society like India. Thus, incorporating inputs through experiences and wisdom in to designing metrics may justify the scope of application of normative perspectives to satisfy the sense of being "good for society". However, the main practical problem that we may confront is the validity of any metrics to varied situations and contexts, although there could be similarities in terms of resources used, technology involved, and the type of customers are being served [13].

For this goal, two ideal forms of measurement methods have been identified: I conversational measurement, which is based on the use of various and ambiguous metrics, and (ii) directional measurement, which is based on the use of a few and unidirectional measurements. Our paradigm outlines the possible methods through which directional and conversational measurement could influence the effectiveness of attention, extension, and creativity. We explain how various degrees of ambiguity, or the inability to clearly understand or discriminate between problems and possible courses of action, may call for various assessment approaches. The main claim is that directional measuring is necessary in low-ambiguity settings because it enables prolonged and continuous attentional concentration. Conversely, more ambiguous circumstances necessitate verbal measurement. This is so that organizational members can think about various concerns and potential courses of action. Conversational measurement engages attention in a bottom-up approach.

The objective of this research paper is to re-examine the parameters of eco-metrics that are related to innovation. To achieve this goal, this study will use secondary qualitative and quantitative data analysis and review existing research published in journals with similar agendas. By employing these methods, the researchers aim to gain a deeper understanding of the current state of innovation-related eco-metrics and identify areas where further research is needed. In other words, this paper aims to contribute to the existing knowledge on innovation-related eco-metrics by exploring the existing literature and analyzing relevant data.

2. Literature review

This section presents some important literature focusing on the aspect of innovation and the related eco-metrics used to measure it in organizations.

Environmental problems brought on by over use of natural resources have prompted the need for a more sustainable, circular, and digital future. While research on eco-innovation and the circular economy has made strides in finding sustainable solutions, the impact of population changes, and digitalization has yet to be fully addressed. The research by Hojnik et al. [14] investigates the implications of demographic shifts and digitalization on eco-innovation and the circular economy business practises. According to interviews with 10 Slovenian businesses, they are adjusting to changing expectations and utilizing digitalization to develop more sustainable goods, resulting in lower energy usage and environmental effect. The findings shed fresh light on the adoption of eco-innovations in the circular economy. Recent studies have recognized green staff (an individual who lacks experience in a specific field or activity is referred to as "green.") as a useful resource for eco-innovation, although empirical research is lacking due to the concept's ambiguity [15,16]. The article by Schmidt-Keilich et al. [17] investigates the potential for eco-innovation of "creative green personnel" by interviewing employees from four small to medium-sized green enterprises in Germany. According to the survey, these employees largely contribute to corporate eco-innovation by producing and debating pro-environmental ideas connected to eco-friendly consumption at work. The findings also imply that these individuals use their environmental expertise, networks, honesty, and business culture of conversation to influence their colleagues' attitudes and actions as environmental role models and opinion leaders [17]. Growing concerns about environmental degradation and the need for businesses to adopt eco-friendly practices have drawn a lot of attention to the intersection of sustainability and business strategy in recent years [18–20]. This has sparked investigation into the motivations behind, effects of, and methods for measuring different facets of green business strategies [21]. Green business strategies are being made possible in large part by digitalization, which makes it easier to incorporate environmental factors into organizational decision-making processes [22,23]. Through the utilization of digital technologies like artificial intelligence (AI), internet of things (IoT), and data analytics, businesses can enhance their environmental performance by optimizing resource utilization and lowering emissions [24–26]. Digitalization makes it possible, for instance, to monitor energy use in real time, maintain machinery predictively to reduce waste, and optimize the supply chain to lower carbon emissions [23,24,27,28]. Thus, developing successful green business strategies requires an understanding of how digitalization promotes eco-innovation and sustainable practices [29,30]. The literature also emphasizes how crucial human capital is to organizations' efforts to promote sustainability and eco-innovation [31,32]. Green staff, which consists of workers with knowledge of renewable energy, sustainable design, and environmental management, are essential in promoting green projects and developing a sustainable culture [33–35]. Their expertise, abilities, and dedication to environmental conservation aid in the creation and application of creative green business plans [36]. Thus, it is crucial to look at how green employees affect organizational sustainability and eco-innovation in order to comprehend the human aspect of green business strategies [37,38]. Furthermore, the literature emphasizes the necessity of accurate eco-innovation metrics in order to evaluate the success of green business initiatives and monitor environmental goal advancement [39,40].

Alamsyah et al. [41] argue that undoubtedly most of the customers prefer eco-friendly products, processes, and services, but that does not mean, they are competent to measure the impact of such products and services. On the other hand, Wu and Chen [42] propose that the value of any eco-friendly product or process must be measured through customers' perception about their attributes or characteristics. As observed by Sheth et al. [43] and a decade later by Sweeney and Soutar [44], there could be some types of perceived values such as functional, social, emotional, epistemic, conditional, and monetary, to evaluate the worth of any eco-friendly innovation. Much later, Chen and Chang [45] argued in favor of similar measurement options to satisfy or address value of innovation, social expectation, environmental protection, and environmental benefit. According to Gallucci et al. [46], eco-innovation is crucial for fostering rapid economic growth in every nation and they have used the Grubel–Lloyd index for measuring the socio-economic performance of an innovation and favored its inclusion in eco-innovation scoreboard measurement. It includes 16 indicators used for measuring performance of EU countries, and they were divided into five distinct components: (1) inputs for eco-innovation (R&D appropriations, staff and researchers and green investments in early stages); (2) environmental innovations (companies that have implemented innovation activities aimed at reducing material and supplying energy per unit of output); (3) Resulting eco-innovation (measured through patents, publications and media coverage); (4) Environmental outcomes, or advantages for the environment as measured by the "productivity" of resources like materials, energy, and water as well as the "intensity" of greenhouse gas emissions; and (5) socioeconomic outcomes (based on performance data of "eco-industries", including those relating to exports, employments and turnover). However, the Grubel–Lloyd index has not been found to be adequately effective to measure intra-industry trade and its impact on environment and sustainability. In their conclusion, Gallucci et al. [46] reiterate that modern society requires new evidence and literature approach to explore more comprehensive and contextually relevant indicators and matrix to measure said impact. The model referred here was used in EU countries and had its own limitations. Hence, it will not be unjustified to assume

that a similar measurement model may not be effective for southeast Asian countries, especially India. Conventional metrics, like the Grubel–Lloyd index, may not fully capture the range of eco-innovations taking place within companies since they largely concentrate on trade-related aspects of environmental performance [46,47]. Consequently, there is an increasing awareness of the shortcomings of current metrics and the requirement for more thorough frameworks to assess eco-innovation along various dimensions, such as organizational procedures, process innovation, and product innovation [40,48]. Researchers can identify gaps in the literature and develop new methodologies, like the proposed index in the current study, to address these shortcomings and provide a more comprehensive assessment of the impact of green business strategies on environmental sustainability. This can be achieved by conducting a systematic review of current measures of eco-innovation and their limitations.

Further, Arundel and Kemp [49] observed that to measure eco-innovation, no one method or metric is likely to be suitable. So, that space must be kept open for research and exploration with prospective indigenous and local perspectives. It is advocated for developing theories on the links between trade, innovation, and environment [50,51]. From the perspective of academic research, innovation measurement is equally crucial. The most prevalent innovation metrics may include the following such as a proportion of yearly sales, the annual R&D spend, number of papers submitted, the percentage of sales that the whole R&D manpower or budget represents, quantity of ongoing projects, number of suggestions made by staff, percentage of sales for items that were just released X years ago (s), Return on investment, Organization capability metrics, and Leadership metrics, etc.

3. Results and discussion

Based on the understanding through literature review and authors own professional experience, some of the most relevant and rational eco-innovation indicators [52–60] may include the following such as Industry R&D spending on environmental protection, percentage of businesses using ISO14001 or EMAS, percentage of businesses with environmental officers or goal statements, the perception of Eco innovation by managers, percentage of the government budget allocated to the "Green Tax", Government spending on environmental R&D as a share of all R&D spending and as a share of GDP, utilizing environmental grants for eco-innovative projects, Financial assistance from government programs for eco-innovation, Demand for environmentally friendly goods, Expenditures on the environment in university and college research, Costs of waste management (landfill tariff etc.), opinion of the executive about environmental regulation (Stringency and transparency), Perceptions of eco-innovation, Number of attendees and frequency of conferences and seminars on eco-innovation, the worth of "green funds" provided by financial institutions to innovative businesses, Managers' views of the general excellence of environmental research in academic institutions, The proportion of market incumbents to eco-startups, Contingents' diversification efforts and investments in minor ventures outside of their core businesses, Eco-patents per million populations in triadic patent families, Environmentally conscious businesses' material productivity (TMR per capita or GDP), and proportion of eco-innovative businesses to all businesses (may need to divide into manufacturing and services).

Innovation is frequently assessed using metrics that emphasize revenue generation, cost containment, and operational effectiveness, but they frequently overlook the effects innovation has on the environment and ecology. By re-examining eco-metrics parameters related to innovation, this research paper seeks to close this gap. We aim to discover and suggest new eco-metrics for evaluating the environmental effects of innovation through secondary qualitative and quantitative data analysis and literature reviews of published research journals with related agendas. Metrics like the percentage decrease in electricity use, fuel consumption for company cars, reductions in carbon emissions, gallons of water saved, and waste diversion are examples of these eco-metrics. Organizations can optimize their environmental footprint and promote sustainable business practices while reducing environmental impact by integrating these eco-metrics into innovation measurement frameworks. By offering useful advice to companies looking to strike a balance between innovation and environmental responsibility, this study adds to the continuing conversation about innovation measurement and sustainability.

The research will conclude with the identification of new eco-innovation-related metrics parameters that can be included in the assessment and better decision making. The details of innovation that can take place for the several reasons namely such as higher caliber, the expansion of the product line, the creation of new markets, lowered labor expenses, enhanced manufacturing procedures, fewer materials used and lighter products Decreased environmental harm, product/service replacement, decreased energy use, and regulatory compliance. Green business model innovation is when a change in business model has an impact on reducing ecological footprint in the lifecycle context. Innovation can be incremental or entirely new. Process of innovation can be measured as input, output/impact, and indirect impact. Data can be collected through surveys, etc. It needs to be measured at the organization, product, and process-level also. Another distinguishing factor could be evaluating the development of new products or the use of new technologies, services, and business methods. Any innovation happening in sustainable business will influence the organization, society, economy, and environment [61]. So, innovation metrics need to be analyzed from all these dimensions. Some of the examples of green business include:

3.1. Green or sustainable business

Businesses that stress social responsibility, economic viability, and environmental sustainability are referred to as "green" or "sustainable" businesses [62–64]. The companies work to maximize their beneficial effects while minimizing their detrimental effects on the environment and society [65,66]. It is frequently used sustainable resources, ecologically friendly technologies, and fair labor methods [67]. Using sustainable business methods has several advantages [68]. One benefit is that it can lessen an organization's carbon footprint and environmental impact, which can result in financial savings and a favorable reputation with customers who value sustainability [69,70]. Also, as workers frequently experience greater fulfillment when working for a company that shares their beliefs, it can result in greater employee happiness and productivity [71]. Finally, because these are more able to adjust to shifting market and regulatory situations, sustainable businesses are frequently better positioned for long-term success and growth [72,73]. In general, businesses are increasingly realizing the need to strike a balance between economic growth and social and environmental responsibility, which has led to a rise in the popularity of green or sustainable company [74]. The dimensions of sustainable development are shown in Fig. 1.

On the other hand, there are some other dimensions explained: (i) Environmental Technologies: The following sub-dimensions are considered for environmental technologies such as technologies for controlling pollution, pollution cleaning technologies and cleaner process technologies, waste management equipment, and noise and vibration control [76,77]. (ii) Organizational Innovations: The following sub-dimensions are considered for organizational innovations such as schemes for preventing pollution, environment auditing and management systems, and efficient chain management minimizing environmental damage [78,79]. (iii) Product and Service Innovation: The following sub-dimensions are considered for product and service innovations such as new product which is environmentally improved e.g., eco-houses and buildings, environmental service: water and waste management, environmental consulting, etc., and less polluting and resource-intensive services [80,81]. (iv) Green System Innovation: The following sub-dimensions are considered for green system innovation such as alternative systems of production and consumption that are better than the existing systems: biological agriculture, etc. [82,83].

Table 1
Existing metrics for organization's perspective.

Input measures	Intermediate output measures	Direct output measures	Indirect impact measures
Organization metrics [84–88]			
R&D expenditures	Number of patents	Number of innovations	Changes in resource efficiency and productivity
Financial subsidies	Waste management cost	Number of patents	Green taxes
Market demand	Number of types of scientific/ academic publications	Executive opinion on regulations	
Environmental subsidies		Manager's opinion on environmental research	
Expenditure in research		Material productivity	
Number of R&D personnel		Data on sales for new products	
Government spending on environmental R&D as a percentage of all R&D spending and as a percentage of GDP			
Frequency of Eco-Innovations workshops and number of people attending it			
Return on investment			
The ratio of green start-ups to incumbents			
Innovation expenditures			
Share of the eco-innovative firm as a percentage of all firms			
Quantity of ongoing projects			
% of sales from items that have been on the market for x years			
Number of ideas submitted			

Fig. 1. Dimensions of sustainable development.
Source: Steinbrink [75].

3.2. Existing metrics as per literature review

The following metrics have been identified from the literature review. Tables 1–3 show the existing metrics for organization's perspective, social perspective and environmental perspective respectively.

3.3. New metrics

The following new metrics have been identified from the literature review. Table 4 discusses about new metrics.

3.4. Understanding of the new metrics parameters

(i) R&D Expenditure is for waste reductions, reduction in resource use, greenhouse gases emissions, pollution Control, etc. These are more specific values that can be mentioned for each area. E.g., Innovation pertaining to water reduction can incur an expenditure. (ii) Percentage Productivity Change: One of the desirable features of innovation is to improve productivity. The amount of change in productivity determines the success or failure of productivity change. (iii) R&D Expenditure as a percentage of sales: Innovation is about capturing market with the implantation of a particular idea (cash is invested). Innovation is successful if it has better market penetration. The amount of R&D expenditure as a percentage of sales. Usually, a 5X ratio is considered appropriate. (iv) Novelty, Usefulness: Qualitative measures specify whether the idea is new and useful to the end-user. Both are qualitative measures. Novelty can be useful for patenting purposes also. (v) Addition of several new products: the quantity of new products added by the organization indicates the innovativeness in the product portfolio listing of the organization. E.g., Samsung introduces many new model numbers with a slight modification of features provided to the end-user. (vi) Improvement in Quality: Social, Environmental, Organization dimensions of improving quality are to be looked upon. The social quality dimension can improve product innovation. Quality training can improve the skills of the employee, thereby improving team performance. (vii) Return on Investment: The effectiveness of innovation is assessed by the returns received during the go-to-market strategy. (viii) Actual vs. Targeted Breakeven time (BET): The success depends on the amount of time in which the invested amount is recovered. Faster the BET, the better the innovation. (ix) time spent by executives on strategic innovation compared to daily tasks: It indicates the amount of time spent on innovative activities. More the percentage, better focus of the organization on innovation activities. (x) percentage of sales or profits from goods or services that were only released X years ago: This is for the launched products in the market. Revenue or profit earned in the past X years determines whether we can continue with the same product in the market or not. (xi) percentage of managers who have received training in innovative concepts and techniques: Several managers/leaders who have undergone innovation concept training. (xii) percentage of projects involving new products, services, or strategies that have executive sponsors: From an organizational perspective, each leader or manager should be assigned to at least one innovative idea or product/service. More the numbers better it is. (xiii) how many managers become CEOs of new categories of businesses: Innovation indicates to the creation of new products and services. Each product and

Table 2
Existing metrics for social perspective.

Input measures	Intermediate output measures	Direct output measures	Indirect impact measures
Social innovation [89–93]			
Newness	Co-patenting activities	Exports of products from eco-industries	
Multiple dimensions of improvement	Triadic patents per million population	Employment in eco-industries	
Qualifying improvements	Firms having National/International collaboration	Turnover in eco-industries	
Sector neutrality		Level of emergence (individuals, org, etc.)	
Attitude towards eco-innovations			
Legitimacy of social needs		Percentage of households having access to broadband/ICT	
Social demands' pressing need		Graduation rates at a doctorate level	
		Entrepreneurship in economies: Perceptions, intentions, and social attitudes	
		Self-employed by birthplace	
		Citizens' attitudes and interests toward science and technology	
		Percentage of respondents that support pursuing the development of new technology despite the fact that it may provide an unknown risk	

Table 3
Existing metrics for environmental perspective.

Input measures	Intermediate output measures	Direct output measures	Indirect impact measures
Environment metrics [84,85,87,94,95]			
The total value of a green early-stage investment	Green patents	Jobs creation green technology industry	
Number of eco-patents		Market size of green industry	
#ISO 140001 registered organizations	Decreased material input to production ratio		
	Decreased energy input to output		
		Implementation of environment regulations	
		Activeness of renewable energy utilization	

service later require a manager/leader to handle it. (xiv) Percentage change in the amount of waste produced and Severity level (Level 1 to 4): Pollutions level is including SO2, NOx, CO, PM10, PM2.5, CHG, Toxins and Run-off. The amount of change between the old level and the new level of pollution, toxins, or run-off. If the percentage change is negative, it means there is a positive impact on the environment and vice versa. (xv) Percentage reduction of electricity usage: Reduction in electricity usage, less the cost in the generation of electricity using fossil fuels, etc. (xvi) Percentage change in fuel consumption for company vehicles: Reduction in electricity usage, less the cost in the generation of electricity using fossil fuels, etc. (xvii) Percentage carbon emissions reductions: Reduction in carbon emissions. Fewer carbon emissions, better for the environment. (xviii) Gallons of water saved: Reduction in water consumption is better for the environment. (xix) Percentage change in properties of water quality namely: it includes Acidity (pH) and Dissolved Solids. More acidity and dissolved solids, more it will be harmful to human beings. (xx) Particulate matter turbidity: More the turbidity, more harmful to human beings. (xxi) Increased waste diversion: More the turbidity, more harmful to human beings. (xxii) Amount of labor and material cost reduced: Lesser material and better quality of material help in reducing the price and passing its value to the customer.

With the help of this study, we aim to examine various measuring techniques and suggest a prospective theory-building procedure based on previously published empirical data as well as our own expertise and knowledge. We think that innovation is a continuous process that is demonstrated by the results of applied R&D that are informed by theoretical knowledge, engineering standards, and knowledge of what can be advantageous for the environment and end users as well as sustainable. Many metrices have been identified from the previous literature and identified in this study. Metrics for innovation are crucial for assessing the effectiveness and impact of green business strategies. Some important metrics we should think about to environment and sustainable development. The carbon footprint reduction statistic calculates how much greenhouse gas emissions a company has cut thanks to its environmentally friendly business practices. This can entail lowering energy use, moving to renewable energy sources, or putting in place sustainable transportation alternatives. By recycling, composting, or using other techniques, a corporation can reduce the quantity of garbage that ends up in landfills. This can be discovering ways to reuse materials or minimizing packaging waste. The water conservation indicator calculates how much water a business has saved by employing water-saving techniques such installing low-flow fixtures, using drought-resistant landscaping, or putting in place water reclamation systems. The renewable energy use metric calculates what proportion of an organization's energy needs are fulfilled by renewable energy sources like solar, wind, and hydropower. The percentage of a company's goods that are manufactured using sustainable materials, are made to be recyclable, or have a lower environmental impact is measured by sustainable product development. The extent of employee involvement in the company's green activities is measured by employee engagement. Participation in volunteer activities, sustainability training, or employee-led green teams are a few examples. The degree of customer involvement in the business's green activities is measured by customer engagement. These could include client comments on environmentally friendly items, client purchases, or client involvement

Table 4
New metrics.

Input measures	Intermediate output measures	Direct output measures	Indirect impact measures
Organization metrics			
More specific metrics: R&D Expenditure for: **a.** Waste reductions **b.** Reduction in resource use **c.** GHG emissions **d.** Pollution Control, etc.			Percentage productivity change
R & D Expenditure in comparison to the number of sales			
Novelty (Qualitative)			
Usefulness		Number of new products added	
		Improvement in quality	
Return on investment			
Actual vs. Targeted breakeven time (BET)		Percentage of executive time spent on innovation compared to daily tasks	
Percentage of sales or profits from goods or services that were released in the last X years		% of managers trained in innovation concepts and techniques	
		% of projects involving new products, services, or technologies that have executive sponsors	
		How many managers become CEOs of new categories of businesses	
Environment metrics			
		Percentage change in the amount of waste produced and Severity level (Level 1 to 4) 1. Pollutions a. SO_2 b. NO_x c. CO d. PM_{10} e. $PM_{2.5}$ f. CHG 2. Toxins 3. Run-off	
		Reduction in electricity use as a percentage	
		Change in percentage of fuel usage for company vehicles	
		Percentage reductions in carbon emissions	
		Gallons of water saved over time	
		Percentage change in properties of water quality namely: 1. Acidity(pH) 2. Dissolved solids Particulate matter turbidity	
		Increased waste diversion	
		Amount of labor cost reduced	
		Amount of material cost reduced	

in environmental causes. Companies can monitor these KPIs to gauge their progress toward sustainability objectives and spot areas where their green business practices need to be strengthened.

4. Theoretical and practical implications

By incorporating environmental considerations into the conceptual framework, the process of conceptualizing and theorizing innovation metrics for green business practices advances the field of innovation theory [96,97]. This integration deepens our understanding of innovation as a complex process that includes environmental sustainability in addition to technological and economic aspects [98,99]. The study closes the gap between innovation theory and sustainability discourse by measuring innovation using environmental metrics [98,100]. It emphasizes how crucial it is to take into account ecological effects in addition to conventional innovation performance metrics, promoting a more comprehensive understanding of organizational innovation processes [101,102]. Measuring models are enhanced by the creation of innovation metrics specific to green business practices, which provide additional factors and perspectives for evaluating innovation performance [103,104]. By improving measurement models' comprehensiveness and validity, this expansion gives academics and industry professionals' stronger instruments for assessing and comparing innovation projects [105,106]. Research on sustainability, innovation studies, environmental science, management theory, and other fields may all provide insights into the conceptualization process [100,107].

Through the cross-fertilization of concepts and methods, this interdisciplinary approach enriches theoretical frameworks and promotes creative thinking in both the academic and practical spheres [108,109].

Organizations looking to match innovation efforts with environmental sustainability objectives can benefit from the conceptualization of innovation metrics for green business practices [97,110]. Organizations can allocate resources and efforts towards sustainable development initiatives that promote eco-friendly innovation by identifying and prioritizing key environmental metrics [111,112]. Organizations can assess how well they integrate environmental considerations into their innovation processes in a systematic manner thanks to the development of standardized innovation metrics [98,113]. Organizations can monitor their progress toward sustainability goals and promote continuous improvement by benchmarking against industry peers and best practices [114,115]. The availability of customized innovation metrics makes it easier for managers and other decision-makers to make data-driven decisions by giving them practical information about how innovation projects will affect the environment [116,117]. In order to ensure alignment with sustainability objectives, this helps organizations to make informed decisions about the allocation of resources, investment priorities, and strategic direction. The ability of organizations to communicate their sustainability efforts to stakeholders, such as investors, customers, regulators, and the general public, is improved through the clear and transparent measurement of environmental performance metrics [118,119]. Strong reporting systems build brand reputation, promote trust, and show an organization's environmental stewardship commitment [120,121]. By identifying and rewarding projects that have a positive environmental impact, green innovation is encouraged when environmental metrics are included into innovation measurement frameworks [103,122]. This encourages staff members to provide concepts and solutions that tackle environmental issues and cultivates an innovative culture that places a high priority on sustainability [123,124].

5. Conclusions, limitations and scope of future opportunities

The study investigates the different methods of measurement and propose a future theory-building process based on our own experience and knowledge as well as previously published empirical data. We believe that innovation is a constant process that is exemplified by the outcomes of applied R&D that are guided by engineering standards, theoretical understanding, and understanding of what can be sustainable and beneficial for the environment and end users. Numerous metrics have been identified in this study and in earlier literature. Innovation metrics are essential for evaluating the impact and efficacy of green business initiatives. A few crucial metrics for the environment and sustainable development that we should consider. The research constitutes a noteworthy advancement in the assimilation of environmental factors into innovation theory and practice. Further insights into the dynamics of green innovation processes can be gained through the creation of innovation metrics specifically designed with environmental sustainability in mind. Through clarifying the connection between innovation and environmental performance, organizations are able to comprehend the mechanisms that propel eco-friendly innovation endeavors with greater depth. The development of green innovation metrics emphasizes how important it is for businesses to coordinate their innovation initiatives with more general sustainability objectives [125]. Organizations can more accurately evaluate their contributions to sustainable development and environmental stewardship by incorporating environmental factors into innovation measurement frameworks. The suggested innovation metrics provide organizations looking to operationalize green business practices with useful advice. Organizations can systematically assess their environmental performance, pinpoint areas for development, and monitor their progress toward sustainability goals by using standardized measurement tools. By providing incentives for environmentally friendly innovation initiatives, the adoption of green innovation metrics holds the potential to stimulate positive environmental impact. Organizations can encourage a culture of environmental responsibility and help to mitigate climate change and resource depletion by recognizing and rewarding sustainability-driven innovation.

The intricacy and contextual specificity of environmental issues may pose difficulties for the development of standardized innovation metrics for environmental sustainability. The generalizability of suggested metrics may be limited by the need for customized approaches to measurement in various industries, geographical areas, and organizational contexts. It could be difficult to apply green innovation metrics if data on environmental performance is not readily available or of high quality. Accessing pertinent data sources, guaranteeing data accuracy, and setting up baseline measurements for comparison can be challenging for organizations. Researcher and practitioner collaboration across disciplinary boundaries including innovation studies, environmental science, and management theory is essential to the conceptualization process. Organizational and logistical challenges may arise when ensuring effective coordination and communication among stakeholders with different levels of experience and viewpoints.

Subsequent investigations may concentrate on conducting empirical validation and testing of suggested green innovation metrics within actual organizational contexts. Research methods such as longitudinal studies and case analyses may be able to shed light on how well these metrics work in various settings and industries. It is important to approach the creation of green innovation metrics as an iterative process open to constant modification and improvement. It is imperative for researchers and practitioners to stay adaptable to evolving trends, technological breakthroughs, and shifting regulatory environments, ensuring that measurement frameworks are updated appropriately. Environmental, social, and governance (ESG) reporting standards are examples of larger sustainability reporting frameworks that could incorporate green innovation metrics. This would improve the sustainability performance of organizations' accountability, transparency, and comparability, enabling stakeholders to make well-informed decisions. Initiatives aimed at knowledge sharing and capacity building among organizations should be implemented in tandem with efforts to develop metrics for green innovation. Workshops, training courses, and cooperative platforms could enable participants to apply green innovation metrics in real-world settings with efficiency.

CRediT authorship contribution statement

Chandravadan Prajapati: Conceptualization, Investigation, Writing – original draft. **Indrajit Goswami:** Investigation, Validation, Writing – original draft. **Vimal Kumar:** Conceptualization, Investigation, Supervision, Writing – review & editing. **Arpit Singh:** Resources, Writing – review & editing. **Seema Mahlawat:** Investigation, Resources, Supervision. **Sumanjeet Singh:** Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

The authors would like to thank the two anonymous reviewers, Associate Editor, and Editor-in-Chief for their valuable comments and suggestions that helped to improve the manuscript.

Funding

The authors received no financial support for the research, authorship and/or publication of this article.

References

[1] P.F. Drucker, The discipline of innovation, Harv. Bus. Rev. 80 (8) (2002) 95–102.
[2] A. Dwivedi, N. Pawsey, Examining the drivers of marketing innovation in SMEs, J. Bus. Res. 155 (2023) 1–12.
[3] J. Pei, The impact of proactive environmental strategies on ecological sustainability of Chinese high-tech industry, Eng. Econom. 34 (1) (2023) 75–88.
[4] F. Ecer, E. Aycin, Novel comprehensive MEREC weighting-based score aggregation model for measuring innovation performance: the case of G7 countries, Informatica (Ljubl.) 34 (1) (2023) 53–83.
[5] A. Frenkel, S. Maital, H. Grupp, Measuring dynamic technical change: a technometric approach, Int. J. Technol. Manage. 20 (2000) 429–441.
[6] R. Cordero, The measurement of innovation performance in the firm: an overview, Res. Policy 19 (1990) 185–192.
[7] W. Park, A. Cullinane, H. Gandolfi, S. Alameh, G. Mesci, Innovations, challenges and future directions in nature of science research: Reflections from early career academics, Res. Sci. Educ. (2023) 1–22, http://dx.doi.org/10.1007/s11165-023-10102-z.
[8] P. Criscuolo, L. Dahlander, T. Grohsjean, A. Salter, Evaluating novelty: The role of panels in the selection of R & D projects, Acad. Manag. J. 60 (2) (2017) 433–460.
[9] T.M. Amabile, R. Conti, H. Coon, J. Lazenby, M. Herron, Assessing the work environment for creativity, Acad. Manag. J. 39 (1996) 1154–1184.
[10] M.A. Abernethy, P. Brownell, Management control systems in research and development organizations: the role of accounting, behavior and personnel controls, Account. Organ. Soc. 22 (1997) 233–248.
[11] M.L. Tushman, Winning Through Innovation: A Practical Guide To Leading Organisational Change and Renewal, Harvard Business School Press, Boston, MA, 1997.
[12] K. Kajtazi, G. Rexhepi, A. Sharif, I. Ozturk, Business model innovation and its impact on corporate sustainability, J. Bus. Res. 166 (2023) 114082.
[13] S.K. Markham, H. Lee, Product development and management association's 2012 comparative performance assessment study, J. Prod. Innov. Manage. 30 (3) (2013) 408–429.
[14] J. Hojnik, M. Ruzzier, M.K. Ruzzier, B. Sučić, B. Soltwisch, Challenges of demographic changes and digitalization on eco-innovation and the circular economy: Qualitative insights from companies, J. Clean. Prod. 396 (2023) 1–9.
[15] S. Parry, Going green: the evolution of micro-business environmental practices, Bus. Ethics: Eur. Rev. 21 (2) (2012) 220–237.
[16] J. Blake, Overcoming the 'value-action gap'in environmental policy: Tensions between national policy and local experience, Local Environ. 4 (3) (1999) 257–278.
[17] M. Schmidt-Keilich, A. Buhl, E. Süßbauer, Innovative green employees: the drivers of corporate eco-innovation? Int. J. Innov. Sustain. Dev. 17 (1–2) (2023) 182–204.
[18] J. Effiong, N. Singhal, Impact of green business model on sustainability management of Indian corporate organisations: A review of issues and opportunities for business growth, FIIB Bus. Rev. 3 (3) (2014) 7–19.
[19] P. Mishra, P. Sharma, Green marketing: Challenges and opportunities for business, BVIMR Manag. Edge 7 (1) (2014) 78–86.
[20] V. Kumar, R. Raj, P. Verma, J.A. Garza-Reyes, B. Shah, Assessing risk and sustainability factors in spice supply chain management, Oper. Manag. Res. (2023) http://dx.doi.org/10.1007/s12063-023-00424-6, Ahead-of-Print.
[21] K. Babiak, S. Trendafilova, CSR and environmental responsibility: Motives and pressures to adopt green management practices, Corp. Soc. Responsib. Environ. Manag. 18 (1) (2011) 11–24.
[22] P.G. Cardinali, P. De Giovanni, Responsible digitalization through digital technologies and green practices, Corp. Soc. Responsib. Environ. Manag 29 (4) (2022) 984–995.
[23] X. Chen, M. Despeisse, B. Johansson, Environmental sustainability of digitalization in manufacturing: A review, Sustainability 12 (24) (2020) 10298.
[24] M. Javaid, A. Haleem, R.P. Singh, R. Suman, E.S. Gonzalez, Understanding the adoption of Industry 4.0 technologies in improving environmental sustainability, Sustain. Oper. Comput. 3 (2022) 203–217.
[25] S. Benzidia, N. Makaoui, O. Bentahar, The impact of big data analytics and artificial intelligence on green supply chain process integration and hospital environmental performance, Technol. Forecast. Soc. Change 165 (2021) 120557.
[26] V. Kumar, A. Mittal, N.K. Sharma, P. Verma, The role of IoT and iIoT in supplier/producer and customer continuous improvement interface, in: Digital Transformation and Industry 4.0 for Sustainable Supply Chain Performance, Springer Nature, Switzerland, 2023.
[27] R. Raj, V. Kumar, B. Shah, Big data analytics adaptive prospects in sustainable manufacturing supply chain, Benchmarking (2023) http://dx.doi.org/10.1108/BIJ-11-2022-0690, Ahead-of-Print.
[28] R. Raj, V. Kumar, P. Verma, Big data analytics in mitigating challenges of sustainable manufacturing supply chain, Oper. Manag. Res. (2023) http://dx.doi.org/10.1007/s12063-023-00408-6, Ahead-of-Print.
[29] C. Mele, T. Russo-Spena, Eco-innovation practices, J Organ. Change Manag. 28 (1) (2015) 4–25.
[30] S.A. Rehman Khan, Z. Ahmad, A.A. Sheikh, Z. Yu, Digital transformation, smart technologies, and eco-innovation are paving the way toward sustainable supply chain performance, Sci. Prog. 105 (4) (2022) 00368504221145648.
[31] M. Păcesilă, C.N. Ciocoiu, Systematic literature review on eco-innovation determinants, Manag. Res. Prac. 9 (3) (2017) 30–44.
[32] T.N. Do, V. Kumar, H.M. Do, Prioritize the key parameters of Vietnamese coffee industries for sustainability, Int. J. Prod. Perform. Manag. 69 (6) (2020) 1153–1176.
[33] K. Rezaei-Moghaddam, Green management of human resources in organizations: an approach to the sustainable environmental management, 2016.
[34] S. Ahmad, Green human resource management: Policies and practices, Cogent Bus. Manag. 2 (1) (2015) 1030817.
[35] N. Mirahsani, O. Azizan, M. Shahriari, G. Rexhepi, A. Najmi, Green culture toward employee green behavior; the mediation roles of perceived support and green identity, Environ. Dev. Sustain. (2023) 1–24.
[36] C.A. Ramus, Organizational support for employees: Encouraging creative ideas for environmental sustainability, Calif. Manage. Rev. 43 (3) (2001) 85–105.
[37] N. Rashid, J. Jabar, S. Yahya, S. Shami, Dynamic eco innovation practices: A systematic review of state of the art and future direction for eco innovation study, Asian Soc. Sci. 11 (1) (2015) 8–15.
[38] Y. Tu, W. Wu, How does green innovation improve enterprises' competitive advantage? The role of organizational learning, Sustain. Prod. Consum. 26 (2021) 504–516.
[39] E.M. García-Granero, L. Piedra-Muñoz, E. Galdeano-Gómez, Measuring eco-innovation dimensions: The role of environmental corporate culture and commercial orientation, Res. Policy 49 (8) (2020) 104028.
[40] A. Xavier, T. Reyes, A. Aoussat, L. Luiz, L. Souza, Eco-innovation maturity model: A framework to support the evolution of eco-innovation integration in companies, Sustainability 12 (9) (2020) 3773.
[41] D.P. Alamsyah, A. Trijumansyah, O.I.B. Hariyanto, Mediating of store image on customer trust for organic vegetables. MIMBAR, J. Sosial Pembangunan 33 (1) (2017) 132–140.
[42] S. Wu, Y. Chen, The impact of green marketing and perceived innovation on purchase intention for green products, Int. J. Mark. Stud. 6 (5) (2014) 81–101.
[43] J.N. Sheth, B.I. Newman, B.L. Gross, Why we buy what we buy: a theory of, 1991.
[44] J. Sweeney, G. Soutar, Consumer perceived value: The development of a multiple item scale, J. Retail. 77 (2) (2001) 203–220.
[45] Y. Chen, C. Chang, Enhance green purchase intentions. the roles of green perceived value, green perceived risk and green trust, Manage. Decis. 50 (3) (2012) 502–520.
[46] T. Gallucci, V. Dimitrova, G. Marinov, Interrelation between eco-innovation and intra-industry trade—A proposal for a proxy indicator of sustainability in the EU countries, Sustainability 11 (23) (2019) 1–13.
[47] V. Kovshov, M. Lukyanova, Z. Zalilova, O. Frolova, Z. Galin, International regional competitiveness of rural territories as a factor of their socio-economic development: Methodological aspects, Heliyon 10 (1) (2024) 1-17.
[48] A.F. Xavier, R.M. Naveiro, A. Aoussat, T. Reyes, Systematic literature review of eco-innovation models: Opportunities and recommendations for future research, J. Clean. Prod 149 (2017) 1278–1302.
[49] A. Arundel, R. Kemp, Measuring Eco-Innovation, UNU-MERIT, Maastricht, The Netherlands, 2009.
[50] J. Cherniwchan, B.R. Copeland, M.S. Taylor, Trade and the environment: New methods, measurements, and results, Annu. Rev. Econ. 9 (2017) 59–85.
[51] J. Cherniwchan, Trade liberalization and the environment: Evidence from NAFTA and U.S. manufacturing, J. Int. Econ. 105 (2017) 130–149.
[52] V. Gente, G. Pattanaro, The place of eco-innovation in the current sustainability debate, Waste Manage. 88 (2019) 96–101.
[53] M. Smol, J. Kulczycka, A. Avdiushchenko, Circular economy indicators in relation to eco-innovation in European regions, Clean Technol. Environ. Policy 19 (2017) 669–678.
[54] L. Dogaru, Eco-innovation and the contribution of companies to the sustainable development, Procedia Manuf. 46 (2020) 294–298.
[55] J. Chen, J. Cheng, S. Dai, Regional eco-innovation in China: An analysis of eco-innovation levels and influencing factors, J. Clean. Prod. 153 (2017) 1–14.
[56] F. Chien, M. Ananzeh, F. Mirza, A. Bakar, H.M. Vu, T.Q. Ngo, The effects of green growth, environmental-related tax, and eco-innovation towards carbon neutrality target in the US economy, J. Environ. Manag. 299 (2021) 1–9.
[57] T. Foxon, M.M. Andersen, The greening of innovation systems for eco-innovation–towards an evolutionary climate mitigation policy, in: DRUID Summer Conference-Innovation, Strategy and Knowledge, Vol. 28, 2009, pp. 1–35.
[58] V. Koval, O. Borodina, I. Lomachynska, P. Olczak, A. Mumladze, D. Matuszewska, Model analysis of Eco-innovation for national decarbonisation transition in integrated European energy system, Energies 15 (9) (2022) 1–19.
[59] B. Orlando, L.V. Ballestra, V. Scuotto, M. Pironti, M. Del Giudice, The impact of R & D investments on eco-innovation: A cross-cultural perspective of green technology management, IEEE Trans. Eng. Manage. 69 (5) (2020) 2275–2284.

[60] R.M. Rodríguez-González, G. Maldonado-Guzman, A. Madrid-Guijarro, The effect of green strategies and eco-innovation on Mexican automotive industry sustainable and financial performance: Sustainable supply chains as a mediating variable, Corp. Soc. Responsib. Environ. Manag. 29 (4) (2022) 779–794.
[61] P. Verma, V. Kumar, P.C. Bhatt, V.A. Drave, S.C. Hsu, K.K. Lai, Industry 4.0 in emerging economies: Technological and societal challenges for sustainability, in: Application and Challenges of Maintenance and Safety Engineering in Industry 4.0, IGI Global, New York, USA, 2020.
[62] A. D'amato, S. Henderson, S. Florence, Corporate social responsibility and sustainable business, in: A Guide To Leadership Tasks and Functions, 2009, p. 102, https://cclinnovation.org/wp-content/uploads/2020/03/corporate-social-responsibility-and-sustainable-business.pdf. (Accessed 24 March 2024).
[63] J. Abbas, S. Mahmood, H. Ali, M. Ali Raza, G. Ali, J. Aman, S. Bano, M. Nurunnabi, The effects of corporate social responsibility practices and environmental factors through a moderating role of social media marketing on sustainable performance of business firms, Sustainability 11 (12) (2019) 3434.
[64] S.K. Jauhar, M. Pant, V. Kumar, N.K. Sharma, P. Verma, Supply chain and the sustainability management: Selection of suppliers for sustainable operations in the manufacturing industry, Chapter 4, in: Sustainability in Industry 4.0: Challenges and Remedies, CRC Press, Taylor & Francis, 2021, pp. 75–93.
[65] M.E. Porter, M.R. Kramer, The link between competitive advantage and corporate social responsibility, Harv. Bus. Rev. 84 (12) (2006) 78–92.
[66] V. D'Angelo, F. Cappa, E. Peruffo, Green manufacturing for sustainable development: The positive effects of green activities, green investments, and non-green products on economic performance, Bus. Strategy Environ. 32 (4) (2023) 1900–1913.
[67] R.E. Cooper-Ordoñez, A. Altimiras-Martin, W. Leal Filho, Environmental friendly products and sustainable development, in: Encyclopedia of Sustainability in Higher Education, 2019, pp. 575–588.
[68] S.N. Morioka, I. Bolis, S. Evans, M.M. Carvalho, Transforming sustainability challenges into competitive advantage: Multiple case studies kaleidoscope converging into sustainable business models, J. Clean. Prod. 167 (2017) 723–738.
[69] B. Willard, The New Sustainability Advantage: Seven Business Case Benefits of a Triple Bottom Line, New Society Publishers, 2012.
[70] D.C. Esty, A. Winston, Green To Gold: How Smart Companies Use Environmental Strategy To Innovate, Create Value, and Build Competitive Advantage, John Wiley & Sons, 2009.
[71] J.H. Gavin, R.O. Mason, The virtuous organization: The value of happiness in the workplace, Organ. Dyn. 33 (4) (2004) 379–392.
[72] N.K. Sharma, W.K. Chen, K.K. Lai, V. Kumar, Sustainability performance measurement methods, indicators and challenges: A review chapter 9, in: Book Titled Sustainability in Industry 4.0: Challenges and Remedies, CRC Press, Taylor & Francis, 2021, pp. 179–199.
[73] N.K. Sharma, K. Govindan, K.K. Lai, W.K. Chen, V. Kumar, The transition from linear economy to circular economy for sustainability among SMEs: A study on prospects, impediments, and prerequisites, Bus. Strategy Environ. 30 (4) (2021) 1803–1822.
[74] P. Verma, V. Kumar, T. Daim, N.K. Sharma, A. Mittal, Identifying and prioritizing impediments of industry 4.0 to sustainable digital manufacturing: A mixed method approach, J. Clean. Prod. 356 (2022) 1–20.
[75] L. Steinbrink, What is sustainable development and why is it so important, 2019, http://emeraldbe.com/sustainable-development-important/ (Accessed 24 March 2024).
[76] M.J. Shehab, I. Kassem, A.A. Kutty, M. Kucukvar, N. Onat, T. Khattab, 5G networks towards smart and sustainable cities: A review of recent developments, applications and future perspectives, IEEE Access 10 (2021) 2987–3006.
[77] V.D. Dragomir, How do we measure corporate environmental performance? A critical review, J. Clean. Prod. 196 (2018) 1124–1157.
[78] D. Ortiz-Avram, N. Ovcharova, A. Engelmann, Dynamic capabilities for sustainability: Toward a typology based on dimensions of sustainability-oriented innovation and stakeholder integration, Bus. Strategy Environ. (2023) 1–36, Ahead-of-Print.
[79] L. Liang, Y. Li, The double-edged sword effect of organizational resilience on ESG performance, Corp. Soc. Responsib. Environ. Manag. 30 (6) (2023) 2852–2872.
[80] J. Shin, Y.J. Kim, S. Jung, C. Kim, Product and service innovation: Comparison between performance and efficiency, J. Innov. Knowl. 7 (3) (2022) 100191.
[81] A. Gustafsson, H. Snyder, L. Witell, Service innovation: a new conceptualization and path forward, J. Serv. Res. 23 (2) (2020) 111–115.
[82] M.L. Paracchini, C. Bulgheroni, G. Borreani, E. Tabacco, A. Banterle, D. Bertoni, G. Rossi, G. Parolo, R. Origgi, C. De Paola, A diagnostic system to assess sustainability at a farm level: The SOSTARE model, Agricult. Sys. 133 (2015) 35–53.
[83] B. Elzen, S. Spoelstra, Developing sustainable livestock production systems. Outline of a learning and experimentation strategy (LES), in: System Innovations, Knowledge Regimes, and Design Practices Towards Transitions for Sustainable Agriculture, 2012, pp. 208–225.
[84] B. Corona, L. Shen, D. Reike, J.R. Carreón, E. Worrell, Towards sustainable development through the circular economy—A review and critical assessment on current circularity metrics, Resour. Conserv. Recy. 151 (2019) 104498.
[85] J. Wilson, P. Tyedmers, R. Pelot, Contrasting and comparing sustainable development indicator metrics, Ecol. Indic. 7 (2) (2007) 299–314.
[86] K.H. Robèrt, Tools and concepts for sustainable development, how do they relate to a general framework for sustainable development, and to each other? J. Clean. Prod. 8 (3) (2000) 243–254.
[87] T.M. Parris, R.W. Kates, Characterizing and measuring sustainable development, Ann. Rev. Environ. Resour. 28 (1) (2003) 559–586.
[88] B. Beloff, D. Tanzil, M. Lines, Sustainable development performance assessment, Environ. Prog. 23 (4) (2004) 271–276.
[89] J. Millard, How social innovation underpins sustainable development, in: Atlas of Social Innovation: New Practices for a Better Future, 2018, pp. 41–43.
[90] G.M. Eichler, E.J. Schwarz, What sustainable development goals do social innovations address? A systematic review and content analysis of social innovation literature, Sustainability 11 (2) (2019) 522.
[91] R. Arocena, J. Sutz, Universities and social innovation for global sustainable development as seen from the south, Technol. Forecast. Soc. Change 162 (2021) 120399.
[92] M.A. Galindo-Martín, M.S. Castano-Martinez, M.T. Méndez-Picazo, The relationship between green innovation, social entrepreneurship, and sustainable development, Sustainability 12 (11) (2020) 4467.
[93] S. Baker, A. Mehmood, Social innovation and the governance of sustainable places, Local Environ. 20 (3) (2015) 321–334.
[94] S.K. Sikdar, Sustainable development and sustainability metrics, AIChE J. 49 (8) (2003) 1928–1932.
[95] B. O'Regan, J. Morrissey, W. Foley, R. Moles, The relationship between settlement population size and sustainable development measured by two sustainability metrics, Environ. Impact Assess. Rev. 29 (3) (2009) 169–178.
[96] R. Bose, X. Luo, Integrative framework for assessing firms' potential to undertake Green IT initiatives via virtualization–A theoretical perspective, J. Strateg. Inf. Syst. 20 (1) (2011) 38–54.
[97] R. Varadarajan, Innovating for sustainability: A framework for sustainable innovations and a model of sustainable innovations orientation, J. Acad. Mark. Sci. 45 (2017) 14–36.
[98] N.P. Melville, Information systems innovation for environmental sustainability, MIS Q. (2010) 1–21.
[99] N.A. Ashford, R.P. Hall, The importance of regulation-induced innovation for sustainable development, Sustainability 3 (1) (2011) 270–292.
[100] B. Truffer, L. Coenen, Environmental innovation and sustainability transitions in regional studies, Reg. Stud. 46 (1) (2012) 1–21.
[101] K. Rennings, Redefining innovation—eco-innovation research and the contribution from ecological economics, Ecol. Econom. 32 (2) (2000) 319–332.
[102] J. Tidd, Innovation management in context: environment, organization and performance, Int. J. Manag. Rev. 3 (3) (2001) 169–183.
[103] M.L. Tseng, R. Wang, A.S. Chiu, Y. Geng, Y.H. Lin, Improving performance of green innovation practices under uncertainty, J. Clean. Prod. 40 (2013) 71–82.
[104] T. Clauss, Measuring business model innovation: conceptualization, scale development, and proof of performance, R & D Manag. 47 (3) (2017) 385–403.
[105] H. Edison, N. Bin Ali, R. Torkar, Towards innovation measurement in the software industry, J. Syst. Softw. 86 (5) (2013) 1390–1407.
[106] M. Rosemann, T. De Bruin, Towards a business process management maturity model, in: ECIS 2005 Proceedings of the Thirteenth European Conference on Information Systems, Verlag and the London School of Economics, 2005, pp. 1–12.
[107] A.I. Gaziulusoy, H. Brezet, Design for system innovations and transitions: A conceptual framework integrating insights from sustainablity science and theories of system innovations and transitions, J. Clean. Prod. 108 (2015) 558–568.
[108] P. Purg, S. Cacciatore, J.Č. Gerbec, Establishing ecosystems for disruptive innovation by cross-fertilizing entrepreneurship and the arts, Creative Ind. J. 16 (2) (2023) 115–145.
[109] P. Meusburger, Milieus of creativity: The role of places, environments, and spatial contexts, in: Milieus of Creativity: An Interdisciplinary Approach To Spatiality of Creativity, Vol. 2, 2009, pp. 97–153.
[110] Y. Fernando, C.J.C. Jabbour, W.X. Wah, Pursuing green growth in technology firms through the connections between environmental innovation and sustainable business performance: does service capability matter? Resour. Conserv. Recy. 141 (2019) 8–20.
[111] B. Albloushi, A. Alharmoodi, F. Jabeen, K. Mehmood, S. Farouk, Total quality management practices and corporate sustainable development in manufacturing companies: the mediating role of green innovation, Manag. Res. Rev. 46 (1) (2023) 20–45.
[112] N. Chams, J. García-Blandón, On the importance of sustainable human resource management for the adoption of sustainable development goals, Resour. Conserv. Recy. 141 (2019) 109–122.
[113] R. Adams, S. Jeanrenaud, J. Bessant, D. Denyer, P. Overy, Sustainability-oriented innovation: A systematic review, Int. J. Manag. Rev. 18 (2) (2016) 180–205.
[114] J. Singh, H. Singh, Continuous improvement philosophy–literature review and directions, Benchmarking 22 (1) (2015) 75–119.

[115] D.B. Costa, C.T. Formoso, M. Kagioglou, L.F. Alarcón, C.H. Caldas, Benchmarking initiatives in the construction industry: Lessons learned and improvement opportunities, J. Manage. Eng. 22 (4) (2006) 158–167.
[116] O. Troisi, G. Maione, M. Grimaldi, F. Loia, Growth hacking: Insights on data-driven decision-making from three firms, Ind. Mark. Manag. 90 (2020) 538–557.
[117] F. Provost, T. Fawcett, Data science and its relationship to big data and data-driven decision making, Big Data 1 (1) (2013) 51–59.
[118] M. Naidoo, A. Gasparatos, Corporate environmental sustainability in the retail sector: Drivers, strategies and performance measurement, J. Clean. Prod. 203 (2018) 125–142.
[119] J. Ranganathan, Sustainability rulers: Measuring corporate environmental and social performance, Sustain. Enterp. Perspect. (1998) 1–11.
[120] A. Amran, S.P. Lee, S.S. Devi, The influence of governance structure and strategic corporate social responsibility toward sustainability reporting quality, Bus. Strategy Environ. 23 (4) (2014) 217–235.
[121] J.S. Toms, Firm resources, quality signals and the determinants of corporate environmental reputation: some UK evidence, Br. Account. Rev. 34 (3) (2002) 257–282.
[122] E.M. García-Granero, L. Piedra-Muñoz, E. Galdeano-Gómez, Eco-innovation measurement: A review of firm performance indicators, J. Clean. Prod. 191 (2018) 304–317.
[123] E.G. Carayannis, J. Morawska-Jancelewicz, The futures of Europe: Society 5.0 and industry 5.0 as driving forces of future universities, J. Knowl. Econ. 13 (4) (2022) 3445–3471.
[124] S. Bertels, L. Papania, D. Papania, Embedding sustainability in organizational culture. A systematic review of the body of knowledge, London, Canada, Netw. Bus. Sustain. 25 (2010) 1–20.
[125] N.M. Suki, N.M. Suki, A. Sharif, S. Afshan, G. Rexhepi, Importance of green innovation for business sustainability: Identifying the key role of green intellectual capital and green SCM, Bus. Strategy Environ. 32 (4) (2023) 1542–1558.