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FOREWORD

Twin transformation aims at synergetic interaction and mutual reinforcement of the digital and sustainable transformation of manufacturing enterprises and associated value-added chains. This introduces several challenges and opportunities for cross- and interdisciplinary research on establishing sustainable, smart, resilient and human-centered manufacturing and supply chain of the future.

Information Control Problems in Manufacturing (INCOM) is a triennial symposium organized by the International Federation on Automatic Control (IFAC). The IFAC Coordinating Committee on Cyber-Physical Manufacturing Enterprises (CC 5) sponsors INCOM, which equally involves Technical Committees on Manufacturing Plant Control (TC 5.1), Management and Control in Manufacturing and Logistics (TC 5.2), Integration and Interoperability of Enterprise Systems (TC 5.3), and Large Scale Complex Systems (TC 5.4).

Technische Universität Wien (TU Wien) and Fraunhofer Austria are delighted to organize the 18th edition of INCOM in Vienna, Austria in August 28-30, 2024. Hosted by the Austrian Federal Economic Chamber (WKÖ), INCOM 2024 has provided a great forum and unique opportunity for exchanging knowledge and discussing theoretical advances, emerging topics and industrial experiences under the **flagship** topic of "**sustainable transformation towards autonomous manufacturing systems**".

Academic and industrial experts joined the event and shared their research results and empirical insights focusing among others on: digital twin, green factories and logistic networks, federated manufacturing platforms, virtualization, global manufacturing, autonomous and self-learnable systems, data-driven industrial engineering, Industry 4.0/5.0's strategies, models, and technologies, human interaction in robotics and cyber-physical systems as well as new advances in additive manufacturing, Physical internet, predictive maintenance, robotics and conversational AI applications in manufacturing and supply chain. At INCOM 2024, five outstanding keynote talks were delivered:

- Prof. Torbjørn H. Netland, ETH Zürich, Switzerland, "Augmented Intelligence for Next-Level Manufacturing Excellence"
- Prof. Dmitry Ivanov, Berlin School of Economics and Law, Germany, "The Future of Supply Chain Simulation and Digital Twins"
- Prof. Alexandre Dolgui, IMT Atlantique, France, "Information Control Problems in Manufacturing: History of IFAC INCOM Symposium"
- Prof. Andreas Kugi, TU Wien and AIT Austrian Institute of Technology, Austria, "Advanced Control for Sustainable Autonomous Manufacturing"
- Caroline Viarouge, EIT Manufacturing, France, "How European Manufacturing is shaping our Greener and Digital Future?"

INCOM 2024 intended to foster synergies among all participants and establish dialogues. To this end, two panels have been organized. The first panel focused on "Smart and Sustainable Manufacturing", with participation of academic experts from IFAC community, and also industrial experts from UNIDO, Infineon Technologies Austria, and EIT Manufacturing. The second panel was dedicated to CC5 involving TC chairs, where the discussion focused on "Resilient, Digital and Sustainable Manufacturing and Supply Chain". Offering a Doctoral Workshop on "Advances in Manufacturing and Logistics Management and Control Problems" as a pre-conference event on August 27, 2024, INCOM 2024 also highly acknowledged the value of next generation scientists and industrial experts. This is also reinforced by delivering Young Author Awards and Best Paper Awards.

To sum up, 360 submissions were reviewed, out of which 218 were accepted and presented at the symposium (acceptance rate: 60.5%). The paper were presented from 39 nations in front of the audience of 340 people. The conference received 42 session proposals, out of which 28 proposals with at least five accepted papers have been appeared on the symposium program. Further, the Doctoral Workshop involved 31 PhD candidates presenting their research proposals and progress to 10 senior advisors.

The current proceeding stores all the papers presented during the INCOM 2024 symposium, representing the current trends and evolution in twin transformation of manufacturing and supply chain. The INCOM 2024's editors would like to acknowledge the efforts of all contributors, namely authors, reviewers, technical associate editors, session organizers and chairs, as well as all IPC and NOC members. During the review process and planning the symposium program, we have been committed and humbly put efforts to assure scientific quality and significant contributions of the IFAC community to the body of knowledge in manufacturing and supply chain.

We, on behalf of all contributors of INCOM 2024, sincerely hope that the present proceedings inspires you on creating, sharing and implementing new ideas towards shaping manufacturing and supply chain of the future. We wish you a pleasant reading.

Vienna, August 2024

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INCOM 2024's Editor and NOC Chair

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INCOM 2024's Editor and NOC Co-Chair

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Sustainability in Servitization: A Review of Assessment Methodologies for the Steel Sector

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Abstract: Due to increasingly stringent environmental regulations, many sectors, including the steel industry, have to think about new strategies to improve their sustainability performance. In other sectors, the adoption of servitized business models has proven to be an effective practice in this respect. For this reason, the steel sector is increasingly looking at this paradigm. However, as there is a lack of clear methodologies for assessing the sustainability of servitized business models, this article aims to identify the most suitable ones through a literature review. In order to provide guidelines within the steel sector then, the work is completed by matching the identified methodologies with a set of criteria useful for assessing servitized business models in this specific sector. The results show how the adoption of Multi Criteria Decision-Making methodologies is more suitable for qualitative criteria, while methodologies such as Life Cycle Cost or Life Cycle Assessment are more suitable for quantitative criteria, although attention must be paid to the identification of the functional unit, or the determination of the system boundaries. Finally, the article also shows which criteria are most relevant to assess the sustainability of servitized business models within the steel sector.

Keywords: Sustainability, Servitization, Product-service system, PSS, Assessment methodology, Business model evaluation, Steel sector.

1. INTRODUCTION

In recent years, global efforts towards sustainable development and climate change mitigation have driven nations and industries to explore innovative strategies. The steel industry, a significant contributor to carbon emissions and energy consumption (Iron and Steel Technology Roadmap - Towards More Sustainable Steelmaking, 2020), faces increasing pressure to decarbonize and align with environmental goals. Initiatives like the European Green Deal (The European Green Deal, 2019), which highlights the necessity of taking immediate action on climate change reaching climate neutrality by 2050, contribute as evidence of this urgency.

To address the environmental challenges of steel production it is necessary to explore diverse approaches, as, for instance, the adoption of "green" technologies (Vogl et al., 2021) or circular practices (Berlin et al., 2022). Among these strategies, servitization emerges as a potential avenue for reducing resource consumption and fostering sustainability (Galimberti, Cimini, & Cavalieri, 2023). Servitization entails a shift from the traditional product-centric approaches to the provision of a combination of products and services (Mont, 2002). Lately, literature suggests that the transition to servitized business models can improve the recycling and reuse of goods, thus promoting the circular economy, considering that recycled components can be used in the same or other applications (Bressanelli et al., 2018). In addition, through continuous technology upgrades and improved maintenance, servitization can also allow for an increase in the useful life of the assets (Khan et al., 2020), thus enabling the use of fewer resources, with consequent environmental benefits.

However, the steel sector lags in servitization awareness and lacks clear methodologies for assessing the potential impact of this particular business model on its process, with respect to the three pillars of sustainability according to the triple bottom line (TBL) (Elkington, 1998), i.e. the economic, environmental and social dimensions.

This article aims to bridge this gap by investigating methodologies for the assessment of servitization opportunities for the steel industry, according to the three dimensions of the triple bottom line, through a comprehensive analysis of literature. The study complements earlier work (Galimberti, Cimini, Copani, et al., 2023) in which criteria for the assessment of servitization opportunities within the steel sector were investigated. In this article, a systematic literature review is conducted to research the methodologies adopted, in the service sector, to assess servitized business models, in order to understand which are the most suitable for the assessment from an economic point of view, which from an environmental point of view and which from a social point of view. In addition, an attempt is made to associate at least one assessment methodology with each criterion identified in the previous work.

The ultimate goal is to provide a guide for steelmakers and technology providers, to encouraging a shift towards more sustainable practices and servitized business models, to meet environmental targets set by policymakers.

The paper is organized as follows: In section 2 a background about servitization and sustainability is presented. The methodology adopted during the research is presented in Section 3. Section 4 deals with the main assessment methods for servitized business models encountered in the corpus of

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articles which are then discussed in Section 5. Conclusion and future work are addressed in the last Section.

2. BACKGROUND

Up until today, the steel sector is strongly tied to the traditional sale model, linked to the purchase, use and then disposal of technologies and equipment. Recently, however, some technology providers in the steel supply chain have shown interest in business models focused on selling the use of a particular technology rather than selling the technology itself (Galimberti, Cimini, Copani, et al., 2023). This interest stems from the belief that, by changing business model, it will be possible to increase revenues and expand the pool of customers. The attractiveness of the concept lies in the possibility to supply an asset to a customer retaining the ownership, and then, after some time, to allocate it to a new customer, after operations such as revamping or retrofitting. Business models of this type fall into the category of result-oriented product-service systems (Tukker, 2004) within the paradigm of servitization, which have proven in other sectors to bring several advantages (Khan et al., 2020). Even though the potential benefit from an economic perspective are evident, a closer look at the model reveals how this kind of approach can bring benefits from an environmental perspective as well, considering that, by undergoing revamping or retrofitting, there is an high probability of extending the useful life of the technologies (Han et al., 2020). Moreover, if the technology manufacturer owns the asset, it will certainly have an incentive to design and build each component to last longer, in order to reduce maintenance expenses (Neely, 2008). Additionally, the manufacturer is supposed to be the one knowing the technology better than anyone else, being the one designing it. For this reason, he should be able to operate it under the best conditions, probably minimising the use of resources and optimising the maintenance operations (Gaiardelli et al., 2014). All these considerations have already been addressed for years in several sectors, but lately it seems to interest the steel sector as well, given the increasingly stringent environmental regulations.

Since this is a new practice for this industry, it is first necessary to define the most suitable methodologies able to assess the different servitization opportunities. While methodologies may be common to several industries, they must refer to criteria specifically defined for a sector in order to address any of its peculiarities. As already pointed out, since a change in the business model creates multiple effects on different perspectives, it is crucial that all three TBL's dimensions of sustainability are assessed, i.e., economic, environmental and social. In this respect, a study has already been carried out to identify the most relevant criteria for the sector (Galimberti, Cimini, Copani, et al., 2023), both from the provider and the customer perspective. These criteria were derived from the servitization literature and then validated with industrial stakeholders in the steel sector. However, some of these criteria are of qualitative and others of quantitative nature. For this reason, it is not conceivable to use the same methodology for all criteria. Therefore, this research aims to overcome this lack by identifying some useful methodologies for the assessment of the proposed criteria, in order to provide guidelines for the assessment of servitized business models for companies operating in the steel sector.

3. METHODOLOGY

In order to achieve the objective of the article, and thus indicate which assessment methods might be most suitable to assess servitized business models from a sustainability perspective, it was decided to adopt a systematic review, which aims at systematically searching and synthesising research evidence, finally providing recommendations for practice and future research (Grant & Booth, 2009). The selection of articles was based on the Scopus database, which represent one of the most comprehensive repositories for the scientific literature in the engineering and management fields.

The first research conducted was: TITLE-ABS-KEY (method* OR model*) AND TITLE-ABS-KEY (servitization) AND TITLE-ABS-KEY (sustainab*) AND TITLE-ABS-KEY (assessment OR evaluation). However, this research only produced 29 articles. To expand the body of papers, it was decided to also include results containing PSS and product-service system. Although the concepts of servitization and product-service system (PSS) are slightly different, they are strongly related, as pointed out by (Baines et al., 2009): "Servitization is the innovation of an organisations capabilities and processes to better create mutual value through a shift from selling product to selling PSS". For the purpose of this paper, it was thus considered that the two terms could be equally relevant.

The new search string used for the analysis was therefore: TITLE-ABS-KEY (method* OR model*) AND TITLE-ABS-KEY (servitization OR pss OR "Product-service system*") AND TITLE-ABS-KEY (sustainab*) AND TITLE-ABS-KEY (assessment OR evaluation). Furthermore, articles published within the last ten years, i.e., from 2014 to 2024, were selected. Moreover, only articles written in English, published in scientific journals and concerning the subject area of "engineering", "environmental science", "decision sciences" and "business management and accounting" were considered in the study.

This second search resulted in 107 articles. After reading the titles and abstracts, the corpus was reduced to 29. Following a complete reading of the articles, 22 of them, describing methodologies for the assessment of servitization and PSS, were selected. Some of the methodologies found, however, focused mainly on the identification of criteria for the assessment of servitized business models, while others more on the assessment itself. For this specific study, it was deemed appropriate to consider only on the latter, which is why the body of papers was reduced to 18. Figure 1 shows a brief summary of the review process.

The low frequency of servitization in the steel sector was confirmed by the fact that none of the 18 selected papers examined technologies or business cases related to the steel production. In order to apply the results to the steel context, it was tried to couple the assessment methods emerging from this literature review with a set of sustainability criteria for the steel sector identified and validated with steel actors in a previous work (Galimberti, Cimini, Copani, et al., 2023).

The rationale followed was therefore to investigate in the corpus of 18 articles which methodologies were applied and which criteria were taken into account. Once a criterion (or a very similar one) that had already been defined in the previous work was identified in one of the 18 papers, the methodology used for its assessment was coupled with it. Since the focus of the work was therefore on how to assess each criterion, it is worth mentioning that some of the analysed methodologies are capable of assessing additional criteria, which, however, are not considered in this study as they are deemed uninteresting in the examined sector.

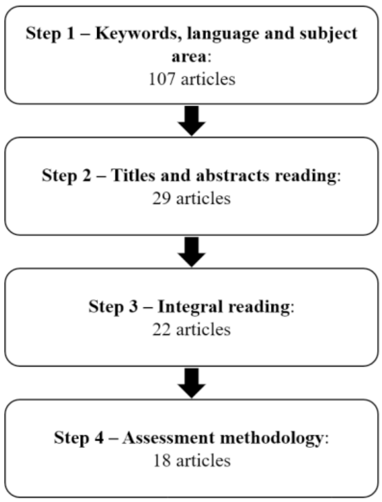

Figure 1. Literature review process

4. RESULTS

First, the methodologies emerging from the selected articles were categorised according to the three dimensions of the TBL which were assessed in the respective article, in order to have a clear view of which methodologies are used for economic (EC), environmental (EN) or social (SO) assessments. The results are presented in Table 1.

Table 1. Assessment methodologies resulted from the review

TBL	Methodology	References
EC	Economic feasibility analysis	(Lanzilotti et al., 2022)
	Total Value of Ownership (TVO)	(Azcarate-Aguerre et al., 2022)
	Life Cycle Cost (LCC) / Life Cycle Sustainability Assessment (LSCA)	(Zhang et al., 2018), (Muñoz López et al., 2020), (Negri et al., 2016)
	Analytical Hierarchical Process (AHP)	(Bertoni, 2019)
	Pugh Method	(Kim et al., 2016)
	Engineering Value Assessment (EVA) method	(Rondini et al., 2020)
	Electre method	(Doualle et al., 2020)
	Probabilistic event-decision trees modelling	(Copani & Rosa, 2015)
EN	Mass balance analysis	(Lanzilotti et al., 2022)
	Life Cycle Assessment (LCA) / Life Cycle Sustainability Assessment (LSCA)	(Monticelli & Costamagna, 2023), (Zheng et al., 2019), (Allais & Gobert, 2016), (Martin et al., 2021), (Zhang et al., 2018), (Kjaer et al., 2018), (Chun & Lee, 2017), (Negri et al., 2016), (Muñoz López et al., 2020)
	Analytical Hierarchical Process (AHP)	(Bertoni, 2019)
	Agent-based simulation	(Koide et al., 2023)
	Engineering Value Assessment (EVA) method	(Rondini et al., 2020)
	Pugh Method	(Kim et al., 2016)
	Electre method	(Doualle et al., 2020)
SO	Social life cycle assessment (SLCA) / Life Cycle Sustainability Assessment (LSCA)	(Sousa-Zomer & Cauchick Miguel, 2018), (Allais & Gobert, 2016), (Negri et al., 2016), (Muñoz López et al., 2020)
	Analytical Hierarchical Process (AHP)	(Bertoni, 2019)
	Pugh Method	(Kim et al., 2016)
	Risk Priority Score (RPS)	(Lanzilotti et al., 2022)

Thus, 8 methodologies were identified for economic, 7 for environmental and 4 for social assessment.

It can also be seen that there were 10 papers addressing the economic perspective, 15 the environmental perspective and 7 the social perspective. Of course, some of the studies assessed more than one perspective, which is why the sum of the assessments is greater than 18.

After this classification, a match was made between them and the criteria relating to the assessment of servitization opportunities in the steel sector. In particular, the economic criteria have been analysed with the distinction between provider and customer point of view (shown in brackets in Table 2 as P or C), due to the fact that between the two perspectives, the criteria could be slightly different, as suggested in vast PSS literature (e.g., (Rondini et al., 2020)). Concerning environmental and social criteria, in the analysed article a clear distinction between provider perspective and customer perspective was not present, so it was decided to assess them indistinctly, assuming that, for the purposes of the assessment methodology, no major differences should emerge. The results are presented in Table 2.

Table 2. Match between criteria and methodologies

TBL	Criteria	Assessment methods
EC	Compatibility with present legislation (P)	Electre method, EVA, Pugh method
	Engineering cost (P)	LCC, EVA, Pugh method
	Implementation cost (P)	LCC, EVA, Pugh method
	Operational and support cost (P)	LCC, EVA, Pugh method
	Disposal cost (P)	LCC, Pugh method
	Network cost (P)	Electre method, EVA
	Return of investment (P)	LCC, Economic feasibility analysis, probabilistic event-decision trees modelling, TVO, Electre method, Pugh method
	Revenue stabilization (P)	EVA, AHP, Pugh method
	Market opportunities (P)	Electre method, EVA, AHP, Pugh method
	Advantage over competition (P)	Electre method, EVA, Pugh method
	Risk (P)	Electre method, AHP
	Willingness to pay (C)	
	Service price (C)	EVA, Pugh method
	Reduced operational cost (C)	Electre method, EVA, Pugh method
	Reduced disposal cost (C)	Electre method, EVA, Pugh method
	Flexibility in transaction mode (C)	Electre method
	Return of investment (C)	Electre method, EVA, AHP
	Convenience of the solution (C)	Electre method, EVA, Pugh method
	Maintenance costs (C)	EVA, AHP, Pugh method

	Assurance on the offer (C)	Electre method, EVA, Pugh method
	Risk (C)	
	Provider readiness (C)	
EN	Energy consumption	LCA, Electre method, Pugh method
	Resource consumption	LCA, Electre method, EVA, AHP, Pugh method
	Water consumption (or pollution)	LCA, AHP
	Greenhouse gas emission (or pollution)	LCA, AHP, Pugh method
	Waste generation	LCA, Electre method, AHP, Pugh method
	Increase the lifecycle of the product	EVA, Pugh method
	Transportation of goods	LCA, Electre method, AHP
	Amount of recycled material	LCA, Electre method, EVA, AHP
SO	Health and safety of the workers	RPS, SLCA, AHP, Pugh method
	Need for training program for the workers	Pugh method
	Expected number of incidents	Pugh method
	Employee satisfaction	SLCA, AHP, Pugh method
	Expanding employment opportunities	Pugh method
	Reducing layoffs	SLCA, Pugh method
	Need for partnership	AHP, Pugh method

5. DISCUSSION

As evident from Table 2, almost all the sustainability criteria for the steel sector, spanning economic, environmental, and social dimensions, have been addressed by at least one methodology. This reassures that the body of 18 articles was able to cover all the multifaceted aspects of the criteria.
Analysing the criteria category by category, some interesting insights emerge. First, looking at the economic ones from the provider's point of view, it can be seen that the use of LCC is prevalent when it comes to quantitative criteria.
Conversely, qualitative criteria are predominantly assessed through Multi Criteria Decision Making (MCDM) methods, as for example Electre, EVA and Pugh. This aligns with the inherent nature of the assessment methods themselves: LCC, dealing with the assessment of all costs incurred across a product's useful life, from the conceptualization, to the production, use, and final disposal (Korpi & Ala-Risku, 2008), proves effective in assessing quantitative criteria. On the other hand, MCDM methods are better suited in capturing the qualitative nuances of criteria, since they are usually based on assessments related to how well the alternative satisfies the criteria or pair-wise comparison of alternatives (Zavadskas & Turskis, 2011). On the customer's side, there is an interesting trend where both quantitative and qualitative economic criteria are assessed through MCDM methodologies. This may stem from the assumption that few researchers measure the profitability of a servitized business model from the customer's perspective. On the contrary, what is often done, in the selected articles, is to measure the customer satisfaction with the service in general, in order to collect insight on how to improve the offering. It is therefore not so necessary to assess the economic perspective in detail when focusing on the customer perspective.
Focusing instead on the environmental dimension, LCA emerges as the predominant method, with 9 out of 15 studies in the category (see Table 1). Here again, the motivation may be related to the purely quantitative nature of the criteria assessed.
Interestingly, both LCC and LCA are used by the vast majority of authors in the assessment of business models, despite having some criticalities to be applied, such as the identification of the functional unit, or the determination of the system boundaries (Allais & Gobert, 2016). Attention must therefore be paid to these aspects before applying these methodologies, which would be more product-related, rather than business-oriented. Once the initial difficulties are overcome, however, these methods could turn out to be very effective for the quantitative assessment of business models as well.
With regard to the social dimension, the analysis showed it to be the least explored territory, given the small number of methodologies identified and by the low average number of criteria considered by the researchers carrying out the analysis. This is probably due to the difficulty of assessing the diverse criteria, which are by nature very qualitative and sometimes subjective and hard to measure, such as employee's satisfaction.
Shifting the focus to the criteria, it can be assumed that those with more studies associated are the most important, since more experts have considered them.
For instance, in the social dimension, "Health and safety" and "Employee satisfaction" are prominent. This may be due to the fact that, as mentioned above, social aspects are poorly investigated in general, so criteria capable of embracing broader concepts are probably preferred to measure generic aspects of wellbeing of the operators. On the other hand, criteria such as "Expected number of incidents" or " Need for training program for the workers " are more specific and therefore probably not chosen when it comes to a low-depth level study. This highlights the need, for future study, to pay more attention to the social dimension, in order to better comprehend the effects of servitization on the workforce.
Within the environmental dimension, the criteria are all very similar and quantitative in nature. In this specific study, the prevailing criteria are "Amount of recycled material," "Waste generation," and "Resource consumption." However, it should be considered that environmental criteria can vary greatly, based on the specific business context. For example, it is likely that in the steel sector the most important criteria are those related to energy consumption, waste generation or greenhouse gas emission, given the numerous articles in the literature regarding the attempt to reduce the impact of these aspects (Galimberti et al., 2022), (Matino et al., 2017).
Regarding the economic perspective, distinct patterns emerge for both customer and provider point of views: from the customer's angle, the criteria that emerge as most relevant are: "Assurance on the offer (C)", "Convenience of the solution (C)", "Reduced operational cost (C)", "Reduced disposal cost (C)". This prevalence confirms the fact that, when analysing the perception of the service from the customer's point of view, overall satisfaction with the service itself matters more than quantitative aspects such as the price or the costs.
On the contrary, "Return of investment (P)" (ROI) stands out as the key criterion from the provider's perspective. ROI turns out to be widely used probably because, beyond revenues, it considers all costs, providing a comprehensive assessment of

the viability of a servitized solution compared to alternatives. Therefore, quantitatively, ROI effectively covers various economic criteria. Additionally, "Market opportunities (P)" emerges as a qualitative economic criterion, highlighting the importance of understanding potential markets and customer needs. In conclusion, a blend of ROI and market opportunities appears to effectively address the provider's viewpoint. This, being a concept common to different sectors, can also be extended to the steel sector.

6. CONCLUSIONS

Starting from the assumption that the adoption of servitization may be able to reduce, to some extent, the environmental impact of industrial processes, this article investigates methodologies capable of assessing servitized business models in the steel sector. The methodological approach stems from a literature review, where methodologies for the assessment of servitization opportunities within the steel sector were identified and categorized, considering the triple bottom line dimensions of economic, environmental, and social sustainability. 13 distinct assessment methodologies were identified in the study, providing an overview of how servitized business models can be assessed across these dimensions. This work also highlights which criteria are most relevant in each of the three dimensions of sustainability.

Main aspects that emerge from the article are that when the intention is to study certain quantitative aspects in detail, the most appropriate solution is to use methodologies that follow the logic of life cycle thinking, such as LCC or LCA, while, on the other hand, when the intention is to give a more qualitative assessment, MCDM methodologies are more appropriate.

The managerial implications of this research lie in providing a guide for steelmakers and technology providers thus aiming to encourage a shift towards more sustainable practices and servitized business models within the steel industry. More specifically, if they were interested in adopting this kind of business models, they could use the presented evaluation methods to identify the most convenient business alternatives, being able to evaluate them from an economic, environmental or social point of view.

From the theoretical point of view, this work contributes to the literature about the assessment of servitized and sustainable business models, shedding light on the importance of considering both quantitative and qualitative aspects in the assessment process. Moreover, while this study specifically focuses on the steel sector, this approach and the outcomes of the work can also be useful for studies in other sectors and could be generally valid for similar industrial segments, such as the process industry at large. Further research could involve the analysis of the long-term evolution and impact of such models or the involvement of some industrial stakeholders, in order to obtain practical cases with which to test the methodologies and the criteria for the assessment of servitized business opportunities. Given the urgence of embedding sustainability concerns in the industrial business development, further studies could also focus on the definition of an integrated quantitative-qualitative assessment method capable to assess at the same time the three perspectives of the TBL to foster more sustainable design of product-service solutions.

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