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Holistic differentiation factors for the strategic design of sustainable production networks

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Abstract

The increasing sustainability influences caused by internal and external stakeholders in the environment of manufacturing companies require a strategy adjustment taking into account the holistic sustainability dimensions. Besides meeting these adapted stakeholder requirements, the transformation also offers opportunities to increase long-term competitiveness by a targeted differentiation. Manufacturing in global production networks is considered to be a decisive lever for realizing competitive advantages. Within the strategic design of global production networks, the manufacturing strategy are specified based on differentiation factors, which have mainly addressed the economic dimension in the form of costs, quality or delivery performance. To meet the changing stakeholder demands and to leverage opportunities for competitiveness, a consideration of the holistic sustainability dimensions within the manufacturing strategy is required. Therefore, this paper aims to expand the differentiation factors of the manufacturing strategy to include the environmental and social sustainability dimensions. For this purpose, existing approaches were identified and analyzed from the perspective of production strategy and sustainability. Conclusively, constituting characteristics of differentiation factors are elaborated and examined for the derivation of the holistic differentiation factors of a sustainable production. Subsequently, existing generic strategy types for the reinforcement of competitive advantages are analyzed. These are further extended to generic strategy types of a sustainable production, taking into account the holistic differentiation factors.

Keywords: Sustainability; Strategy; Manufacturing Strategy; Differentiation Factors; Global Production Networks

1. Introduction

Global production networks provide a fundamental basis for manufacturing companies to ensure competitiveness through a strategic design of the value creation distributed in the network [1]. The global network structures achieve advantages to improve competitive position by developing specific capabilities, such as the exploitation of resources or markets as well as the realization of economies of scale or cost advantages [2]. The adaptation of the complex structures of global production networks is associated with high investments and the time-consuming development of internal and external structures, resulting in the limitation of future strategic options [3]. As a result, consideration of long-term influences on the future competitive environment is essential in order to set the course for long-term competitiveness within the strategic design of the production network [4]. While traditional strategies of global production networks primarily considered economic factors due to high competitive and cost pressures [2], the megatrend of sustainability is changing this paradigm [5].

The increasing sustainability demands of stakeholders in the environment of manufacturing companies require a strategy adjustment taking into account the holistic

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sustainability dimensions [6,7]. Production is a key lever in achieving the manufacturing company's overall objectives [8], making production strategy a central function in the strategy adjustment process. The direction of the strategic objectives of global production is based on differentiation factors [9], which have focused primarily on the economic dimension [2]. Although competitive advantages are feasible along the environmental and social dimension [10], the integration of these dimensions has not been considered in the context of the differentiation factors of production strategy. As a result, managers of global production networks lack experience in sustainability-driven strategic design and require new methods due to the changed business environment [11]. In this context, the objective of this paper is the elaboration of holistic differentiation factors for the strategic design of sustainable production networks.

The remainder of the paper is structured as follows. Section 2 defines the concept of differentiation factors and highlights the relevance of sustainability. Further, section 3 presents an overview of existing approaches, while section 4 introduces the approach to elaborate differentiation factors along the holistic sustainability dimensions.

2. Relevance of differentiation factors and sustainability

Competitive strategies are significantly driven to differentiate from the competition in order to provide unique value to the market [12]. For the strategy development and the corresponding competitive advantages, different perspectives are considered. The external perspective of the *market-based view* suggests that corporate success depends primarily on the attractiveness of the industry as well as the company's market position [13]. In contrast, the internal perspective of the *resource-based view* considers a company's resources and core competencies for market selection [14]. In addition, the *institution-based view* includes the institutional environment, consisting of formal (e.g. laws and regulations) and informal institutions (e.g. culture and norms) [15]. These perspectives are considered along the strategy levels of manufacturing companies, which are subdivided into corporate strategy, business unit strategies and functional strategies [16]. As an element of the functional strategies, the production strategy contributes to ensure the competitiveness of the company [17]. This is provided by decisions to realize the targeted manufacturing structure, infrastructure and required capabilities [18].

The direction of the production strategy is concretized at the company level by means of *differentiation factors* [8]. The differentiation factors are directly influenced by the existing resources and capabilities of a manufacturing company and are to be aligned with the superior strategy levels [17]. By combining these resources and capabilities, competitive advantages are achieved by adapting more efficiently to changes in the market or increasing demands on production [14]. The four main differentiation factors include cost, quality, delivery and flexibility, which have been extended by innovation and service [8,19]. PORTER classifies competitive strategies into the two generic *strategy types* of low cost as well as differentiation [20]. Consequently, different production strategy types based on capability profiles result from a combination of the differentiation factors [19]. Based on the targeted differentiation factors, the required capabilities of the production network are determined, which in turn guide the design of the network structure and infrastructure [9].

Considering the established differentiation factors, the primarily focus on the economic dimension becomes evident. However, according to the three-dimensional model, the economic, environmental and social sustainability dimensions have to be considered equally [21]. The increasing sustainability requirements from the stakeholders of global manufacturing companies require an implementation of this concept by considering the holistic sustainability dimensions in strategic management. Due to the central position of production in manufacturing companies, sustainability goals can only be achieved if sustainability aspects are taken into account within the production strategy [22]. In order to ensure the implementation and control of the sustainable strategy in the context of production, sustainable production indicators (SPIs) can be applied [23]. These represent initial approaches to derive the strategic goals of production, integrating the social and environmental sustainability dimensions. Converting these measurable indicators into strategic differentiation factors for production presents a current deficit.

3. State of the art

The approaches to determine differentiation factors along the holistic sustainability dimensions can be divided into two main perspectives: Approaches from a *production strategy perspective* focus on the economic perspective of differentiation factors. In addition to identifying and validating differentiation factors, these also define generic production strategy types. These strategy types are classified along possible production strategies based on the combination of prioritized differentiation factors [24]. Approaches from a *sustainability perspective* are based on the SPIs and thus also integrate the environmental and social sustainability dimensions. Although these approaches thus do not present differentiation factors, these approaches are included as a basis for deriving holistic differentiation factors. Based on the thematic focus and representative inclusion of existing prior work, the presented papers represent the most relevant.

3.1. Approaches from a production strategy perspective

FROHLICH AND DIXON [25] validate the taxonomy of MILLER AND ROTH [19] in their study. Thereby, they review the applicability of the taxonomy in the modern, dynamic and global production environment. The underlying differentiation factors were developed within an empirical approach in the form of a taxonomy for production strategies [19]. Three resulting strategy types are validated using different data sets and examined by geographic differences.

The typology of production strategies by CAGLIANO ET AL. [24] focuses in particular on the different strategy types. Four basic strategy types are conceptually derived on the basis of a literature review. Subsequently, the four types are

empirically examined, whereby the focus is on the change over time.

In the approach to implement hybrid production strategies, DEFLORIN [24] subdivides the established differentiation factors into nine factors. Based on a survey, the evaluation of the differentiation factors in the form of a Likert scale identifies clusters which are interpreted as strategy types.

The approach of REMLING AND FRIEDLI [2] for the design of the production strategy is based on [8] and builds analogously to the previous approaches on the established differentiation factors. These are divided into nine factors and considered for validation in the form of a prioritization framework taking into account order qualifiers and order winners.

The approaches presented are based on fundamental approaches to differentiation factors [19,27-29] and can thus be considered representative. These approaches define the production strategy on the basis of differentiation factors. Furthermore, strategy types are derived from a corresponding prioritization. The method thus describes top-down how the production strategy, as a functional strategy, specifies goals which result in a selection of differentiation factors. Measurable indicators are then used for the operational implementation.

3.2. Approaches from a sustainability perspective

In contrast to the approaches from a production strategy perspective, SPIs focus explicitly on measurable indicators along the sustainability dimensions. By aggregating the individual SPIs, strategic decision areas are presented that are comparable to the differentiation factors from a production strategy perspective. Thus, the approaches on SPIs represent a bottom-up approach.

The approach of VELEVA AND ELLENBECKER [30] contains six main aspects to which 22 SPIs are assigned. The main aspects consist of energy and material use, natural environment, economic performance, community development and social justice, workers as well as products.

In their approach, KRAJNC AND GLAVIČ [31], structure 89 indicators along ten main aspects according to the three sustainability dimensions. The environmental sustainability dimension is additionally divided into input and output indicators.

Based on VELEVA AND ELLENBECKER [30], the approach of FAN ET AL. [32] classifies the main aspects into the three sustainability dimensions. The approach also includes a total of 32 SPIs that are assigned to the main aspects.

The approach of WINROTH ET AL. [23] focuses on individual factories. Five main aspects are classified according to each sustainability dimension, to which the total of 52 SPIs are assigned.

In addition to the approaches explicitly focused on SPIs in the literature, it is also possible to apply general frameworks such as the sustainability manufacturing toolkit [31]. The sustainability framework of the Global Reporting Initiative (GRI) [32] presents a suitable option, as the basic framework is intended especially for multinational manufacturing companies with a global supply chain. The approaches on SPIs [21,28-21] identified in a systematic literature review show a high degree of similarity and differ only in the number and focus of the indicators. Furthermore, no strategy types are derived on the basis of the indicators.

The approaches from the production strategy perspective provide a comprehensive methodological basis for differentiation factors, which is, however, limited to the economic sustainability dimension. Approaches from a sustainability perspective address all sustainability dimensions, but are not methodologically linked to differentiation factors and strategy types. Thus, there is a deficit in the existing research and the elaboration of holistic differentiation factors is required.

4. Elaboration of holistic differentiation factors

The approach aims to provide support for managers of global production networks to consider the holistic sustainability dimensions in the development of the production strategy. The required elaboration of holistic differentiation factors for the strategic design of sustainable production networks is divided into two steps. The first step is to determine holistic differentiation factors that cover all three sustainability dimensions. On this basis, generic strategy types for sustainable production are developed in a second step.

4.1. Differentiation factors of sustainability dimensions

Based on the results of the literature review, the approaches from a production strategy and sustainability perspective as well as the associated differentiation factors are analyzed in a consolidated form. The differentiation factors derived are listed and presented with regard to their mention in the context of the approaches analyzed.

The analysis of the approaches from a production strategy perspective results in six economic differentiation factors, which can be subdivided into a total of eleven differentiation factors, see Table 1.

Table 1. Differentiation factors from a production perspective.

		[19]	[25]	[26]	[27]	[28]	[29]
Price/Costs (1)	Price (1a)	x	x	x			
	Costs (1b)				x	x	x
Quality (2)	Conformance (2a)	x	x	x	x	x	x
	Performance (2b)	x	x	x	x	x	x
Delivery (3)	Speed (3a)	x	x		x	x	x
	Dependability (3b)	x	x	x	x	x	x
Flexibility (4)	Design (4a)	x	x			x	x
	Product line (4b)	x	x	x			x
	Volume (4c)	x	x	x		x	x
Innovation (5)				x		x	
Service (5)		x	x	x			

In the context of the differentiation factors price and costs, it is noticeable that the use is evenly distributed, but is not

used twice in any approach. This is due to the different perspectives; approaches from a market-based view consider price, while the resource-based view consider cost. However, since the present approach combines the different perspectives, both differentiation factors are included in the further analysis.

The analysis of the approaches from a sustainability perspective results in the differentiation factors energy, resources, waste, emissions, natural environment, product, economy, employees, social justice and community development. The factors resources, employees and social justice are further subdivided into materials, water, health and safety, working conditions, training and education, diversity and equal opportunities, as well as human rights. In total, the analysis provides 14 differentiation factors, see Table 2. Furthermore, there is a high degree of consensus between the different approaches, with eleven of the 14 factors being mentioned by more than half of the approaches and seven factors being mentioned by at least five of the six approaches.

Table 2. Differentiation factors from a sustainability perspective.

Differentiation factor		[30]	[29]	[32]	[33]	[23]	[34]
Energy		x	x	x	x	x	x
Resources	Material	x	x	x	x	x	x
	Water		x		x		x
Waste			x		x	x	x
Emission			x	x	x	x	x
Biodiversity		x			x	x	x
Product		x	x	x	x		
Economy		x	x	x		x	x
Employee	Health & work safety	x	x	x		x	x
	Working condition	x	x	x		x	x
	Training & education	x		x		x	x
Social justice	Diversity & equal opportunity			x		x	x
	Human rights			x			x
Community development		x	x	x		x	x

Based on the definitions of differentiation factors [9,26], three constituent characteristics of differentiation factors are derived: They specify strategic objectives (1), contribute to the increase of competitiveness (2), and indicate a production focus (3). If a factor presents all three constituent characteristics in the course of the individual analysis, it is considered to be one of the elaborated differentiation factors.

The eleven differentiation factors from a production strategy perspective are assigned to the economic dimension due to their economic focus. The factors product and economy from a sustainability perspective are assigned to the economic dimension. However, these are very generally formulated and do not constitute new factors as they are already covered in more detail by the factors from the production strategy perspective. The factors energy, resources, waste, emissions and natural environment are assigned to the environmental sustainability dimension. The social dimension, on the other hand, includes the factors employees, social justice and community development. In addition, the primary perspective (market, resource or institution-based view) of the differentiation factors is analyzed along the sustainability dimensions, see Table 3.

Table 3. Holistic differentiation factors along the sustainability dimension.

Sustainability dimension	Differentiation factor		Perspective
Economic	Price/Costs	Price	Market
		Costs	Resources
	Quality	Conformance	Market
		Performance	Market
	Delivery	Speed	Market
		Dependability	Market
	Flexibility	Design	Market
		Product line	Market
		Volume	Market
	Innovation		Market
	Service		Market
Environmental	Energy		Resources
	Resources	Material	Resources
		Water	Resources
	Waste		Resources
	Emission		Institution
	Biodiversity		Institution
Social	Employee	Health & work safety	Resources
		Working condition	Resources
		Training & education	Resources
	Social justice	Diversity & equal opportunity	Resources
		Human rights	Institution
	Community development		Institution

4.2. Generic strategy types for sustainable production

The clustering of differentiation factors results in specific competitive advantages, whereby this clustering results in strategy types of manufacturing companies. The strategy types can be divided into the basic types of low cost and differentiation [20], with the latter being subdivided into market-based, resource-based and technology-based strategies [24]. Within the analysis of existing scientific approaches five approaches were selected, which consolidate further approaches to generic production strategy types and are therefore considered to be representative. For each of the strategy types presented within the approaches, the corresponding key differentiation factors are indicated in Table 4, according to the notation of Table 1.

The analysis of the approaches in the literature as well as the derived strategy types shows that so far only economic differentiation factors have been used. However, this is not sufficient for a comprehensive and sustainable production strategy. With consensus of the analyzed approaches, the strategy types are consolidated and conceptually extended by differentiation factors of the environmental and social sustainability dimension.

Table 4. Production strategy types.

Strategy category		[19]	[25]	[24]	[26]	[9]
Low-price	Price	1a,2a,3	1a,2a,3	1a,2		1a,2
Differen-tiation	Market		2,3,6	2,3,6	2b,3b,6	1a,2,4,6
					2a,3,4c,6	
	Resources	1a,2,3,4b	1a,2,3,4,6		1a,2b,3,5,6	
				1a,2,4,6	2,3	2,3,4c,5,6
	Technology	1a,2,3b,4a,6	2,3,4a,6	2,4b		2,4b,5,6

With consensus of the analyzed approaches, the strategy types are consolidated and listed as five types. The *price-focused* strategy type of the price-based strategy includes the differentiation factors price, quality and delivery. The *customer-focused* and *expert* strategy types result from the market-based strategy category. The focus of the differentiation factors of the *customer-focused* strategy type is on service, quality and either flexibility or delivery. In contrast, the differentiation of the *expert* is based on factors that change over time and are specifically composed. The resource-based strategy category results in the *classic* strategy type, which focuses on the differentiation factors quality, delivery, volume flexibility and service. Finally, the *innovator* of the technology-based strategy is differentiated by quality, innovation, service, design and product line flexibility as well as delivery dependability.

Based on the derived holistic differentiation factors for the strategic design of sustainable production, the identified strategy types are expanded to include environmental and social differentiation factors. Differentiation factors are distinguished between primary and secondary. Primary differentiation factors represent the main targets of each strategy type, while secondary differentiation factors support the main target. The strategy types expanded by the holistic differentiation factors can be found in Table 5. Production strategy types consist of multiple differentiation factors that can be achieved holistically through global production networks that overcome focused location capabilities.

In addition to the price, the *price-focused* strategy type includes the primary differentiation factors energy and emissions. Due to rising energy costs as well as taxation or fines for exceeding emissions, the reduction of energy consumption and emissions leads to the realization of environmental goals and the simultaneous reduction of costs. Secondary differentiation factors include health and work safety and working condition. By maximizing these factors, a minimization of downtime is achieved.

Resulting from a market-based strategy and the goal of differentiation through environmental and social factors, the differentiation factors for the *customer-focused* strategy and the *expert* are company-specific based on market environment.

The primary differentiation factors of the *customer-focused* strategy type are the economic factors service and quality. Secondary differentiators include flexibility, delivery, energy, resources, waste, emissions, and social justice to meet customer requirements. These are taken into account in the customer's decision or required by the customer as basic features and thus form the foundation for successful market differentiation.

Table 5. Holistic differentiation factors for each strategy type.

Strategy type	Economic	Environmental	Social
Price-focused	**Price**, **Costs,** quality, delivery	**Energy**, **emission**	Health & work safety, working condition
Customer-focused	**Service**, **quality**, flexibility or delivery	Energy, resources, waste, emission	Social justice
Expert	**Quality**, **delivery**, **service**, **price**, product line	**Emission**, energy, **resources**, waste	Social justice
Classic	**Quality**, **delivery**, volume flexibility, service	Resources	Employee
Innovator	**Quality**, service, **innovation**, design and product line flexibility, delivery dependability	Energy, resources, waste, emission	**Training & education**, working condition

Primary differentiation factors indicated in bold

The *expert's* differentiation factors are based on factors that change over time in order to respond flexibly to changing customer requirements. Primary differentiation factors from the environmental dimension are resources and emissions, as competitive advantages can be achieved through resource-conserving and low-emission production. Energy, waste and social justice are also areas through which the expert can gain a competence advantage, which are therefore classified as secondary differentiation factors.

The *classic* strategy represents the model of a constant, successful company over decades and is based on established economic values such as quality, delivery, volume flexibility and service. The strategy is based on a resource-based strategy and focuses on long-term customer satisfaction built on company-specific knowledge. In order to secure these values and maintain company-specific knowledge within the company, resources and employees are considered as secondary differentiation factors.

With innovation as the central differentiation factor, the *innovator* is characterized by innovative technologies and high quality products. The strategy focuses also on the primary differentiation factor of training and education. Highly qualified and well-trained employees, in combination with a productive working environment, are the key to high-quality innovations. The secondary differentiation factors of energy, resources, waste, emissions and working conditions support and ensure the primary factors, which form the basis of the innovator strategy type.

5. Conclusion and further research

In this paper, differentiation factors of production strategies along the holistic sustainability dimensions are outlined. The changed environment of manufacturing

companies in the context of sustainability requires an adjustment of the strategic design of global production networks. Considering the increasing influence of sustainability, existing approaches in research indicate the lack of integration of all three sustainability dimensions, mainly focusing on the economic dimension of differentiation factors. Therefore, this paper focused on expanding the differentiation factors of production strategies to include environmental and social sustainability dimensions. Based on existing approaches from a production strategy and sustainability perspective, holistic differentiation factors of sustainable production were analytically derived. Subsequently generic strategy types for sustainable production, taking into account the derived differentiation factors, were presented. This approach serves as a tool to help managers of global production networks take into account the holistic sustainability dimensions in the production strategy elaboration.

In order to refine the results, different further researches are possible. The proposed approach enables manufacturing companies to identify strategic fields of action for production. For a holistic production strategy, however, these must be further specified. This means that individual targets have to be formulated for individual, high-priority differentiation factors, which can be addressed by the production network capabilities. The developed holistic differentiation factors and generic strategy types, which are based on primarily empirically developed strategy types, show further research potential. Through an empirical study based on the identified 23 holistic differentiation factors of production strategy, these as well as the strategy types can be validated and potentially improved.

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References

[1] Lanza, G., Ferdows, K., Kara, S., Mourtzis, D., Schuh, G., Váncza, J., Wang, L., Wiendahl, H.-P., 2019. Global production networks: Design and operation. CIRP Annals 68 (2), 823–841.

[2] Remling, D., Friedli, T., 2021. The St. Gallen Management Model for International Manufacturing Networks. In: Friedli, T., Lanza, G., Remling, D. (Eds.), Global Manufacturing Management., Springer, Cham, 25–50.

[3] Ferdows, K., 2014. Relating the firm's global production network to its strategy. In: Johansen, J., Farooq, S., Cheng, Y. (Eds.), International operations networks, Springer, London, 1–11.

[4] Porter, M. E.; Heppelmann, J. E., 2014.) How smart, connected products are transforming companies. Harvard Business Review, October, 64–88.

[5] Rauch, E., Dallinger, M., Dallasega, P., Matt, D.T., 2015. Sustainability in Manufacturing through Distributed Manufacturing Systems (DMS). Procedia CIRP 29,544–549.

[6] Burritt, R. L., Christ, K. L., Schaltegger, S., 2020. Multinational Enterprise Strategies for Addressing Sustainability. J Bus Ethics 164, 389–410.

[7] Henisz, W.; Koller, T.; Nuttall, R., 2019. Five ways that ESG creates value - Getting your environmental, social, and governance (ESG) proposition right links to higher value creation. McKinsey Quarterly.

[8] Skinner, W., 1969. Manufacturing - missing link in corporate strategy. Harvard Business Review, 47(4), 136–145.

[9] Friedli, T., Mundt, A., Thomas, S., 2014. Strategic management of global manufacturing networks: aligning strategy, configuration and coordination. Springer, Berlin, Heidelberg.

[10] Masoumik, S. M., Abdul-Rashid S. H., Olugu, E. U., Ghazilla, R. A. R. 2015. A strategic approach to develop green supply chains. Procedia CIRP 26, 670–676.

[11] Steier, G. L., Benfer, M., Lanza, G., 2022. Decision support models for strategic production network configuration. Procedia CIRP 107, 1433–1438.

[12] Porter, M. E., 1996. What is strategy? Harvard Business Review 74 (6), 61–78.

[13] Porter, M. E., 1980. Competitive strategy: techniques for analyzing industries and competitors. Free Press, New York.

[14] Barney, J., 1991. Firm resources and sustained competitive advantage. Journal of Management 17(1), 99–120.

[15] Peng, M. W., Sun, S. L., Pinkham, B.,Chen, H., 2009. The institution-based view as a third leg for a strategy tripod. Academy of Management Perspectives 23(3), 63–81.

[16] Hofer, C. W., Schendel, D., 1978. Strategy formulation: analytical concepts. West Pub. Co., St. Paul.

[17] Dombrowski, U., Intra, C., Zahn, T., Krenkel, P., 2016. Manufacturing strategy – a neglected success factor for improving competitiveness. Procedia CIRP 41, 9–14.

[18] Hayes, R. H., Wheelwright, S. C., 1984. Restoring our competitive edge: competing through manufacturing. John Wiley & Sons, New York.

[19] Miller, J. G., Roth, A. V., 1994. A taxanomy of Manufacturing Strategies. Management Science 40(3), 285-304.

[20] Porter, M. E. 1985. The competitive advantage: creating and sustaining superior performance. Free Press, New York.

[21] United Nations, 1993. Report of the United Nations conference on environment and development. United Nations, New York.

[22] Johansson, G., Winroth, M., 2010. Introducing environmental concern in manufatcuring strategies. Management Research Review 33(9), 877-899.

[23] Winroth, M., Almström, P., Andersson, C., 2016. Sustainable production indicators at factory level. Journal of Manufatucring Technology Managment 27(6), 842-873.

[24] Cagliano, R., Acur, N., Boer, H., 2005. Pattern of change in manufacturing strategy configurations. International Journal of Operations & Production Management 25(7), 701-718.

[25] Frohlich, M. T., Dixon, J., 2001. A taxonomy of manufacturing strategies revisited. Journal of Operations Management 19(5), 541-558.

[26] Deflorin, P., 2007. Fähigkeiten zur Umsetzung hybrider Produktionsstrategien in der Schweiz. Dissertation, St.Gallen.

[27] Ferdows, K., Meyer, A., 1990. Lasting improvements in manufacturing performance: In search of a new theory. Journal of Operations Management 9(2), 168-184.

[28] Miltenburg, J., 2009. Setting manufacturing strategy for a company's international manufacturing network. International Journal of Production Research 42(22), 6479-6203.

[29] Slack, N., Lewis, M., 2002. Operations strategy. Financial Times Prentice Hall, Upper Saddle River.

[30] Veleva, V., Ellenbecker, M., 2001. Indicators of sustainable production: framework and methodology. Journal of Cleaner Production 9(6), 519-549.

[31] Krajnc, D., Glavic, P., 2003. Indicators of sustainable production. Clean technologies and Environment Policy 5(3-4), 279-288.

[32] Fan, C., Carrell, J. D., Zhang, H.-C., 2010. An investigation of factors for measuring sustainable manufacturing. Proceedings of the 2010 International Symposium on Sustainable Systems and Technology, 1-5.

[33] OECD, 2011. OECD Sustainable manufacturing toolkit. Seven steps to environmental excellence. https://www.oecd.org/innovation/green/toolkit/48704993.pdf. Accessed 15 February 2023.

[34] Global Reporting Initiative 2021. GRI 1: Foundation.