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The Conceptualization of Sustainability in Operations Management

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Abstract

Regardless of the pervasiveness of sustainability, a deeper understanding of sustainable operations management is still needed. The aim of this article is to provide theoretical foundations of sustainability (environmental) in operations management, based on which patterns of sustainability operations strategies could be researched. Thus, sustainability (environmental) is first positioned within the enterprise on the managerial and operational level. Secondly, a framework depicting the relationships, impacts, functions and limits of sustainability as an operations strategy is designed. Thirdly, operationalized from the previous concept, a process for the planning of sustainability operations strategies is designed and proposed.

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1. Introduction

Operations Strategy plays a crucial role in linking business strategy with Operations and is faced with at least two essential challenges. The first one is to formulate an Operations Strategy that is in line with the business strategy and the environment and secondly to implement it. Those challenges become even greater when dealing with sustainability, as it is a novel operations strategy that can be extremely hard to effectively formulate (plan) [1] and implement [2], [3], as it is too often vaguely defined in business strategies. Paradoxically, the trend of sustainability is spreading very fast among manufacturing enterprises. Nonetheless, managers are aware that they risk of failing in dealing with sustainability (Berns et al., 2009). Consequently middle and operations managers need guidance on managing Operations Strategies focused on sustainability, for which much more research need to be undertaken. However, even though that many definitions of sustainability exist, none offer enough details needed to clearly delineate and position the concept of sustainability into a manufacturing enterprise in order to undertake systematic research, based on which

sustainability related patterns, guidelines and methods with strong managerial implications could be derived. Namely, research should be able position sustainability initiatives into existing the strategic and operations managements of manufacturing enterprises. By positioning it clearly, it would enable managers to align it with their existing manufacturing and business strategies, thus additionally bridging the potential gap between management and operations.

Therefore the aim of this article is to build stronger theoretical foundation in the field of sustainability (only environmental) in manufacturing enterprises that would enable the design of strategies, guidelines and theories, that will help increase the effectiveness and efficiency of the implemented sustainability initiatives into existing operations. Concretely, this means that the exact role of sustainability in manufacturing enterprises has to be identified; by role it is meant the “characteristic or expected behavioral pattern in a particular setting” or also “the function performed by something in a particular situation or process” [4]. Furthermore, the concept has to be delineated and positioned within the manufacturing enterprise, while being aware that they are contingent [5] upon factors like industrial,

market and legislative context. As the paper focuses on the field of manufacturing, which is extremely resource intensive, the article targets only the operational level. Consequently, the research question of this paper goes as following: “How can sustainability (environmental) within a manufacturing enterprise be holistically defined in operations management?” The results have to provide solid foundations for research. In order to provide the answer, one objective is to be met – the concept of sustainability will be conceptualized within the level of operations management of a manufacturing enterprise. This will be achieved through two sub-objectives based on Reynolds [6]. The first one is to define the limits, which will be done by positioning sustainability within an enterprise on both levels - strategic and operational; this way the concept will be delineated clearly. The second sub-objective is to define linkages (relationships) among the concepts, thus depicting the relations among sustainability strategy and sustainability operations, their management and finally their relation to diverse industries, markets and legislatives. Among others, the article will not provide only the core questions in relations to sustainability, but also where to start researching sustainability according to its posing and what kind of methodological tools are still lacking to perform a systematic research in order to identify hidden patterns and/or best practices. The results will be beneficial mostly for the research of Sustainability in manufacturing enterprises with the specific aim further on to identify best practices and develop guidelines about developing sustainability initiatives and implementing them.

In the following section, the methodology and the main concepts are briefly introduced. Then in the third section, sustainability is first positioned within the manufacturing enterprise, in strategic and operations management. Afterwards, in the second part of the section the linkages with the concept of sustainability on the operational level are depicted, which will result in the conceptualization of sustainability in operations management. Lastly, this concept is partially operationalized.

2. Methodology

Three main steps are undertaken. The first two steps result in the conceptualization of sustainability on the operational level, while the third provides potential paths for further research. Therefore, the following steps will be:

- The limits are set by defining the concepts involved, which provides the ‘building blocks’ for theorizing [6]; this will enable to position sustainability into the levels of operations strategy and operations.

- Afterwards linkage (relationships) among the concepts will be created [6], depicting the forces impacting sustainability and the relations with the main managerial functions.
- Possibilities of theoretical evolvement of sustainability are than presented.

After defining the role and impact of sustainability, thus identifying “what is it”, it is defined how this can be effectively and efficiently managed. Furthermore, the nexus of the presented framework relies on theoretical foundation arising from strategic management.

3. Concepts

There are two main concepts involved in the article – sustainability and operations management.

There exist multiple definitions of sustainability, where the Triple Bottom Line depicts clearly the relations. Nonetheless, this article focuses only on environmental sustainability (eco-efficiency and eco-effectiveness). However, when talking about managing sustainability, we do not call upon only efficiency measures, but also upon sustainability strategies enabling to modify the current business models that are based on the idea to sell as much products as possible, hence not being adequate in terms of sustainability [7]. Hence, a need for managing sustainability as an operation strategy and an operation arise. Based on definitions of multiple authors, Starik and Kanashiro [8] defined sustainability management as the formulation, implementation, and evaluation of both environmental and socioeconomic sustainability-related decisions and actions. While other management theories explained the need for and advancement of sustainability management, none of those theories appear to have the unique features, benefits, opportunities, challenges, or orientations to assist individuals, organizations, and societies to move toward sustainability as much and as soon as appears necessary [8]. Furthermore, Schrettle et al. [9], based also on other findings, identify that it is still unclear why certain enterprises adopt sustainability practices while others do not and under which circumstances firms can realize competitive advantage by their adoption. Consequently, there is also no descriptive model, which supports decision making of firms facing sustainability challenge [9], while managers especially lack the right information upon which to base decisions and when enterprises do act, their execution is often flawed [1]. Hence, more research on the topic of sustainability with the objective to design dedicated managerial guidelines that will be capable to be aligned with specific operational context is needed; hence being capable to align specific set of complex manufacturing

operations with the business strategy when formulating and implementing a sustainability project. Therefore, it is necessary to identify how sustainability can be formulated and deployed through operations management.

Academics and practitioners who believe that the study of operations is limited to operational matters are fundamentally misunderstanding the contribution of operations management to strategy and, more importantly, the huge potential that operations has to deliver sustainable competitive advantage [10]. Thus, environmental sustainability is not only about pure operations but also about their strategies. Some authors recognize sustainability to be a sustainable operations strategy [11]. According to Bettley [11] operations strategy has been defined as the major decisions about, and strategic management of: core competencies, capabilities and processes, technologies; resources and key tactical activities necessary in any supply network, in order to create and deliver products or services and the value demanded by a customer.

Corbett [12] proposes a typology for sustainable operations management that is based on the life cycle stages of a product and the three dimensions of sustainability. Although very simplified, it points towards the direction towards a basis for systematic research of sustainability in operations management, through which theory advancement can be undertaken. Namely, still today there exist no frame enabling systematic classification of operations strategies focused on sustainability that can be also put into context. There has been some effort within the broader context of operations management to develop taxonomies (Adam, 1983), though operations strategy literature is still quite weak on taxonomical research, both at the conceptual and empirical level [13], although that through this mechanism hidden patterns and configurations can be discovered, which would benefit operations managers.

4. Sustainability in Operations Management

First sustainability is positioned within the enterprise, where the concept is defined through its delineation. In this section, limits of sustainability and relations with other relevant concepts are set, through which its functionalities are described.

4.1. Positioning of Sustainability within the enterprise

The role and positioning of sustainability in strategic and operations management has first to be established. It is also the first step in setting the limits to the conceptual framework. In Figure 1, two main levels are depicted (horizontally) - strategic management and operations management. The former defines the business development path of the enterprise, thus defining a business strategy and diverse business tactics. Moreover, it acts as a boundary for operations management, because the objective of the operations strategy is to support as much as possible the business strategy in its predefined competitive advantages; thus the business strategy acts as the boundary of operations strategy. The focus of this article is solely on the bottom layer, thus on Operations Management (with bolded borders in Figure1). Figure 1 has three columns, the first one showing the decision levels in the enterprise that could be called also the main categories, the second one represents sub-classes

of possibilities within each of the two main classes. In this column, sustainability is classified, with the aim to position it in the multilevel framework of the enterprise. As the third column briefly depicts examples of sustainability positioned in the various levels.

From a strategic management perspective, sustainability can be seen as a business tactic, which role is to support a business strategy (e.g. help increase product differentiation through sustainability in the product design, thus creating the possibility to access to a new customer base). However, this article does not try to advance research in strategic management; hence, the perspective of sustainability as a business tactic is not analyzed, however it was needed to clarify the role of sustainability. At this point, the question is where sustainability can be positioned within the level of operations management?

First, the intent is to position sustainability as an operations strategy, making it a specific type of it. According to Slack and Lewis [14], Operations Strategy is defined as the total pattern of decisions which shape the long-term capabilities of any type of operations and their contribution to the overall strategy, through the reconciliation of market requirements with operations resources. This would mean that a sustainability operations strategy would have to define (propose) a pattern of decisions impacting its operations – thus it is chosen which operations are to be implemented, their capabilities and the pattern of usage. However, still arising from Slack's and Lewis' definition, it must take into account the impact of market requirements, while making an impact (supporting) on the existing overall business strategy. This calls for an alignment between the sustainability operations strategy with the market and the business strategy, however about the alignment more later. Hence, sustainability can be seen as an operations strategy, if it fulfills those requirements. Secondly, sustainability is positioned within operations. This means that multiple types of operations have the characteristics of being sustainable (environmentally) or are applied in such way to have a sustainable impact on a specific part of the value chain. This classification is not novel, as for instance sustainable operations improve the competitive position, as such initiatives are proven difficult to replicate [15]. This article will not employ the term "sustainable operations", as it implies that an operation is sustaining (pertaining), which does not indicate the usual meaning that is targeted (decrease of environmental impact); hence the term "sustainability operations" will be used instead, indicating operations with characteristics or effects of sustainability. Consequently, sustainability can design a sustainability operations strategy, for which sustainability optimized products, with the aim to support its existing business strategy of product differentiation [16]. From the business tactic the operations strategy is developed (although depends on the enterprise, it can be done directly from the business strategy), which has a higher level of details. In this case, the operations strategy focused on sustainability represents the improvement of the product design and its functionalities (energy) in terms of sustainability. Of course, an operations Strategy does not provide such low level of detail, but it is enough to make our point. Finally, in order to implement such sustainability operations strategy specific operations that are sustainability, oriented have to be implemented, like R&D in energy

	Decisional levels	Positioning of Sustainability	Exemplification of Sustainability
Strategic Management	Business Strategy	<ul style="list-style-type: none"> Differentiation Price Differentiation and price 	<ul style="list-style-type: none"> Differentiation
	Business Tactics	<ul style="list-style-type: none"> Sustainability tactic Other tactics 	<ul style="list-style-type: none"> Green and energy optimized product
Operations Management	Operations Strategy	<ul style="list-style-type: none"> Sustainability Strategy Others (e.g. P-S) 	Green product: <ul style="list-style-type: none"> improve design product efficiency
	Operations	<ul style="list-style-type: none"> Sustainability Operations Others 	<ul style="list-style-type: none"> R&D in energy efficiency Energy monitoring process

Figure 1: Positioning of Sustainability in the enterprise

efficiency, dedicated energy monitoring procedures, product design etc. From this short example, it is visible that the sustainability operations strategy is bounded by the business strategy, while sustainability operations are bounded by sustainability operations strategy. Consequently, sustainability operations strategy must take into account the targeted competitive advantages coming from the business strategy and the existing competitive priorities coming from the manufacturing strategy. Thus, it is seen that sustainability operations strategy is not an independent strategy.

After defining the potential roles of sustainability at the operations management level, the following section analyzes to which other internal and external elements is related to sustainability, in which mode and how can those concepts within an enterprise be managed. Therefore, the next is addressed as the “management of sustainability”. At his point, the conceptualization of sustainability in operations management will be concluded.

4.2. Managing Sustainability

Sustainability can be managed as an operations strategy and/or as operations. Hence, sustainability operations strategy and its sustainability operations are undividable and must be analyzed together, so to analyze how they can be managed.

Any idea starts with first making a strategy and then operationalizing it. Therefore, we lean on the rich existing literature of strategic management to understand how a sustainability operations strategy goes from an idea state to an actual operation. For this Huff's [17] framework presenting dimensions of strategic process research was used. More

exactly, this means that we divide the process in two separate steps - strategy formulation and implementation. Strategic process research deals with those two steps. Finally formulation and implementation of Sustainability Operations Strategy can be researched first in a prescriptive form (“how things are done”) and then based on the previous results using a normative approach (“how things should be done”) [17], bringing improvements into the research field. Consequently, the following two questions can be derived from the research framework for sustainability operations strategy presented in Figure 2: a) How to formulate a sustainability operations strategy? How to implement it?

In the second step, the questions about formulation and implementation were linked with the basic managerial functions, with the objective to bring out concrete questions that have to be answered during each of those two phases. In the strategy formulation fits the managerial function of “planning”, through which must be designed all relevant information to perform the implementation, which is the second step. In this step, the plan is executed. The formulation of the strategy is in the domain of the sustainability operations strategy, while the actual implementation, is taking place in the lower level of operations. The formulation step answer the 5 key questions:

The first one is “Where” (in the value chain) – The place of impact of the sustainability operations strategy has to be defined, it is the core information upon which researchers and managers can direct their selves. However, it has to be defined in such way it will be understandable to managers as well as technical staff, thus making a sort of “bridge” between the strategic and operational world. This calls upon the design of a dedicated sustainability taxonomy encompassing the entire

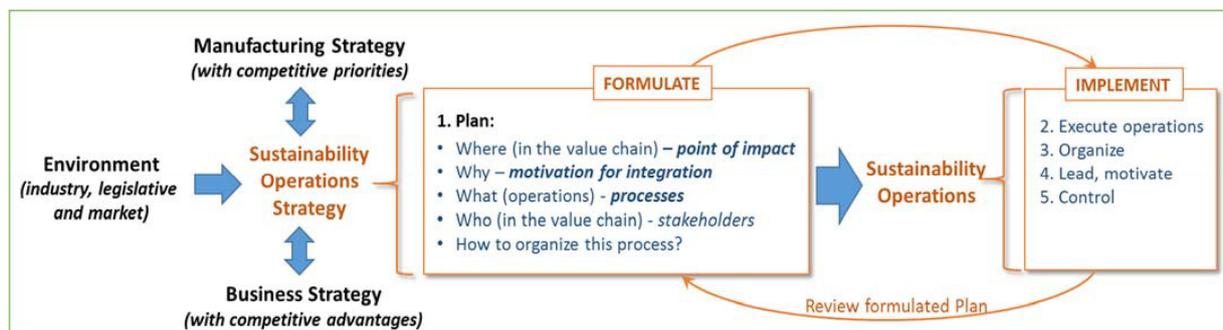


Figure 2: Sustainability in Operations Management

manufacturer's value chain. It would not provide only a common meaning, but moreover it would represent a basis for further classification and analyses through which new information, that are not visible at the first glance, could be derived; for instance groups which are best characterized by the "gestalt" of the communalities they share [18]. Unfortunately, studies using taxonomies to characterize the strategic posture of operations are limited [19], and the one dedicated to sustainability in manufacturing are, as far our knowledge goes, nonexistent. Such taxonomy would also enable researchers to link the "where" with the "how", where management is more interested in the first question, whereas technical experts are more related to the second question. Thus, such taxonomy could be seen as the bridge between management and operations. The second question is "Why" – The motivation for integration of the sustainability strategy must be clear; it can arise from the legislative environment and result as compliance to regulation, can motivate to a cost reduction strategy or supporting a growth strategy. The third one is "What" – What sustainability operations (processes) are needed to execute the sustainability operations strategy has to be identified. Again at this point, a common representation of the activities throughout the manufacturer's value chain is needed, so to be able to pinpoint the operations that are going to be affected by the change. Such common representation shows also a basis for controlling and monitoring. The fourth one is "Who" (in the value chain) – Which stakeholders are involved; this information is derived after defining the place of impact and the operations involved, as only then the amount of change is known. The fifth is "How" to organize this process.

Based on those answers not only managers can easier design their operations strategies, but also research can design research tools like typologies. The two most essential questions in sustainability operations strategies in the planning phase are the "where", "why", which are also the primary starting points of research in sustainability operations strategy. Those two questions can be answered by operationalizing partially the concept of sustainability from Figure 2; first the information from the environment (i.e. industry, legislative, market) are needed, secondly within the enterprise the business strategy has to be identified and thirdly the priorities of the manufacturing strategies that need to be supported (reinforced) must be identified as well. According to those needs, the most adequate sustainability strategy(-ies) can be chosen. The relations among those elements are depicted on Figure 3 in a form of planning procedure of sustainability strategies. For instance, a manufacturing enterprise, due to pressure from the rising prices of electrical energy and decreasing prices of competing products, chooses to additionally reinforce its price based business strategy; for which it has to increase its capability to sell at lower price – this is the price-based priority of manufacturing strategy. Consequently, managers in this case can choose a sustainability strategy of energy efficiency in the manufacturing process that will reduce consumption of energy, optimize the process, while increasing the capability to reduce price. Consequently, all the levels are supportive among each other, thus aligned. Two types of alignment are present in this procedure (Figure 3):

- **Internal alignment** – first the business strategy has to be aligned with manufacturing strategy [20] (i.e. quality, manufacturing flexibility, delivery etc.), while the last has to be aligned with sustainability operations strategy(-ies).
- **External alignment** – first the legislative environment; if it supports a specific set of sustainability operations, it is worth considering it. Secondly, the market competition, where one can benchmark itself against competition on an existing market and obtain new insight. Thirdly, the industry specific should be taken into account.

With those information (from Figure 3), managers can support their procedures for planning sustainability strategies. However, as far as our knowledge goes, no knowledge base linking business, manufacturing and sustainability strategy is present, thus leaving the concept of Sustainability operations management (figure 2) and its dedicated procedure for planning sustainability strategies (figure 3) at a conceptual level.



Figure 3: Procedure for planning Sustainability Operations Strategies

5. Conclusion

The research resulted in a framework for the management of sustainability as an operation strategy as also an operation, where their effectiveness and efficiency is contingent upon the internal and external environment of the enterprise. At this point, the results of the article were beneficiary mostly for research that can use the concept to identify best practices and guidelines in setting-up and implementing sustainability operations strategies, hence enabling managers to exploit more effectively as also efficiently sustainability in their manufacturing enterprise. The first result positioned sustainability in operations management (figure 1), by defining clear roles and limits. Consequently, it has been found out that sustainability is an operations strategy. The second result conceptualized sustainability in operations management (figure 2), in the role of a strategy. The choice of sustainability strategies in operations management is contingent upon the environment (i.e. market, industry and legislative), business strategy and manufacturing strategy. The third result, that is a partial operationalization of the previous one, shows the relations among those elements and how they can be used to

help managers of manufacturing enterprises to support their planning procedure of sustainability strategies (figure 3).

As seen, the two most relevant questions to be addressed when planning a sustainability operations strategy is to identify the business motivation (“why”) and “where” in the value chain should be the impact. However, those results are on conceptual level and a clear link between business strategies, manufacturing strategies and sustainability operations strategies has to be established. This requires to identify hidden patterns and relations, consequently creating the link between the “why” and the “what”.

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References

- [1] M. Berns, A. Townend, Z. Khayat, B. Balagopal, M. Reeves, M. S. Hopkins, and N. Kruschwitz, “The business of sustainability: what it means to managers now,” *{MIT} Sloan Manag. Rev.*, vol. 51, no. 1, pp. 20–26, 2009.
- [2] M. J. Epstein and M.-J. Roy, “Sustainability in action: Identifying and measuring the key performance drivers,” *Long Range Plann.*, vol. 34, no. 5, pp. 585–604, 2001.
- [3] L. B. Cruz, E. Á. Pedrozo, and V. de F. B. Estivaleta, “Towards sustainable development strategies: A complex view following the contribution of Edgar Morin,” *Manag. Decis.*, vol. 44, no. 7, pp. 871–891, Jan. 2006.
- [4] “Oxford English Dictionary,” *Oxford University Press*, 2014. [Online]. Available: <http://www.oed.com/view/Entry/166971?rskey=Bv22lg&result=1#eid>. [Accessed: 18-Aug-2014].
- [5] J. R. Galbraith, *Designing complex organizations*. Addison-Wesley Pub. Co., 1973.
- [6] P. D. Reynolds, *Primer in Theory Construction*. Allyn & Bacon, 1971, p. 191.
- [7] M. Garetti and M. Taisch, “Sustainable manufacturing: trends and research challenges,” *Prod. Plan. Control*, vol. 23, no. 2–3, pp. 83–104, 2012.
- [8] M. Starik and P. Kanashiro, “Toward a Theory of Sustainability Management Uncovering and Integrating the Nearly Obvious,” *Organ. Environ.*, vol. 26, no. 1, pp. 7–30, Mar. 2013.
- [9] S. Schrette, A. Hinz, M. Scherrer -Rathje, and T. Friedli, “Turning sustainability into action: Explaining firms’ sustainability efforts and their impact on firm performance,” *Int. J. Prod. Econ.*, 2013.
- [10] N. Slack, “Operations strategy: will it ever realize its potential?,” *Gestão & Produção*, vol. 12, no. 3, pp. 323–332, 2005.
- [11] A. Bettley and S. Burnley, “Towards Sustainable Operations Management Integrating Sustainability Management into Operations Management Strategies and Practices,” in *Handbook of Performability Engineering SE - 53*, K. Misra, Ed. Springer London, 2008, pp. 875–904.
- [12] L. M. Corbett, “Sustainable operations management: A typological approach,” *J. Ind. Eng. Manag.*, vol. 2, no. 1, pp. 10–30, Jul. 2009.
- [13] E. E. Adam and P. M. Swamidass, “Assessing Operations Management from a Strategic Perspective,” *J. Manage.*, vol. 15, no. 2, pp. 181–203, Jun. 1989.
- [14] N. Slack and M. Lewis, *Operations Strategy*. Prentice Hall, 2011, p. 464.
- [15] S. Gupta and O. D. Palsule-Desai, “Sustainable supply chain management: Review and research opportunities,” *IIMB Manag. Rev.*, vol. 23, no. 4, pp. 234–245, Dec. 2011.
- [16] M. E. Porter, “What is strategy?,” *Harv. Bus. Rev.*, pp. 4–21, 1996.
- [17] A. S. Huff and R. K. Reger, “A Review of Strategic Process Research,” *J. Manage.*, vol. 13, no. 2, pp. 211–236, Jun. 1987.
- [18] D. Miller and P. H. Friesen, “STRATEGY-MAKING IN CONTEXT: TEN EMPIRICAL ARCHETYPES,” *J. Manag. Stud.*, vol. 14, no. 3, pp. 253–280, May 2007.
- [19] C.-C. Sum, L. S.-J. Kow, and C.-S. Chen, “A taxonomy of operations strategies of high performing small and medium enterprises in Singapore,” *Int. J. Oper. Prod. Manag.*, vol. 24, no. 3, pp. 321–345, Jan. 2004.
- [20] M. T. Frohlich and J. R. Dixon, “A taxonomy of manufacturing strategies revisited,” *J. Oper. Manag.*, vol. 19, no. 5, pp. 541–558, Oct. 2001.