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Concept for ambidextrous management of incremental and radical innovation in manufacturing

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Abstract

Innovation managers constantly seek to improve manufacturing systems using continuous improvement as a core process. On the other hand, significant technological advances promise to improve manufacturing systems' performance radically. Therefore, manufacturing units must be able to deal with complex and volatile environments and at the same time act explorative and exploitative to produce both incremental and radical innovations. The organizational ability to achieve this balanced target state is called ambidexterity. The challenge of continuously increasing efficiency while at the same time developing and integrating radical innovation into the manufacturing system has grown enormously in recent years. Consequently, a severe challenge is imposed on the innovation management of the manufacturing unit. This implies ambidexterity management in manufacturing, encouraging organizational research to identify relevant design dimensions and describe concrete managerial implementation measures in a manufacturing context.

Therefore, this paper presents an approach to enable ambidextrous innovation management in manufacturing, fostering radical innovation. Relevant organizational dimensions and their interconnections are identified using scientific literature and expert interviews. In addition, examples of concrete managerial implications for implementing ambidexterity in manufacturing are presented.

Keywords: Manufacturing; Innovation Management, Manufacturing Innovation Management, Ambidexterity, Radical Innovation, Incremental Innovation, Exploration, Exploitation

1. Introduction

Manufacturing companies face an increasingly dynamic environment with partially discontinuous changes caused by three central elements in particular: Unpredictability [1], global competition [2], and rapid technological developments [3]. As a result, continuous profitability and long-term competitiveness are becoming more complex, as competitive advantages are more temporary than ever [4]. Consequently, securing the long-term competitiveness of manufacturing units depends on their ability to implement radical innovation projects [5], as these promise significant performance increases regarding quality, cost, and time [6]. To meet these challenges, the focus of manufacturing units can no longer be solely on achieving short-term operational goals but must also be on achieving strategic advantages. Therefore, concepts are needed to strengthen the strategic innovation capacity of manufacturing units.

The tension between incremental and radical innovations has already been described by Abernathy [7] as the productivity dilemma followed by Christensen's [8] innovator's dilemma. Essentially, the authors argue that the organizational behaviors to constantly produce more efficiently or integrate radical technological changes seem incompatible. Therefore, there is a practical and scientific need to elaborate approaches for the simultaneous management of radical and incremental innovation activities in manufacturing. The organizational ability to simultaneously manage both innovation activities is referred to as ambidexterity [9]. Consequently, it is necessary to strengthen the innovation capacity of manufacturing units transferring the concept of ambidexterity into the manufacturing context. However, the scientific understanding of ambidexterity management (AM) in manufacturing is still in its early stages and lacks holistic models and concrete implementation measures to establish ambidexterity.

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Therefore, this paper aims to present a first approach to establishing AM in manufacturing.

2. Objective and research methodology

The scientific process of the "*Design Research Methodology*" (DRM), according to Blessing & Chakrabarti [10], guides this paper. The DRM consists of four phases: *Research Clarification*, *Descriptive Study I*, *Prescriptive Study*, and *Descriptive study II*. This paper focuses on the first three phases and deals with formulating the research objectives based on a literature review. The literature analysis and semi-structured expert interviews are utilized to generate findings and design a conceptual approach for AM in manufacturing. Concerning the fourth phase, an initial study is provided by describing the consequences of the conducted research and preparing the results for use by others. The following three research questions guide this paper:

- *RQ#1: How can ambidexterity management improve innovation management in manufacturing?*
- *RQ#2: How should an approach for ambidexterity management in manufacturing be conceptualized?*
- *RQ#3: What managerial measures enable a successful implementation of ambidexterity management in manufacturing?*

The research builds upon a precise specification of the terms innovation and ambidexterity management (section 3) using literature-review methods. Subsequently, existing scientific approaches and ten semi-structured interviews are examined to tackle the research questions, which leads to a conceptual framework for AM in manufacturing (section 4). Closing, section 5 provides a critical discussion of the presented approach followed by avenues for further research (section 6) and a summary (section 7).

3. Terms and definitions

3.1. Manufacturing Innovation Management

Schumpeter [11] defines innovation in manufacturing as recombining forces and objects to produce something different or produce differently. Further, Porter adds that two central elements are necessary to characterize an innovation. First, an invention is needed that aims to distinguish an existing process from its initial state. Second, this invention must be successfully implemented and improve the initial state [12].

Innovations can be distinguished in various ways. Regarding research on AM, the differentiation into incremental and radical innovation is particularly relevant. Improvements with a high affinity to the existing product or process, tapping their underlying potential through minor changes, are referred to as incremental innovation [13–15]. In contrast, radical innovation describes a leap or fundamental change that leads to a breakthrough towards a new product or process with significantly better performance [13, 16, 15]. Thus, a process improvement is also understood as a radical innovation if the previously existing potential range is exceeded qualitatively or quantitatively by redesigning relevant process components [15]. Further, radical innovation is present if the process complexity has increased significantly within the respective company, even if the applied concept is already known within other sectors or companies [17, 18].

To identify, develop and integrate radical and incremental innovation in manufacturing processes and managerial methods are necessary. Hence, Manufacturing Innovation Management (MIM) is designing processes and methods to identify, develop and integrate both types of innovation. Further, MIM creates organizational environments, strategies, and culture for innovation in manufacturing. To summarize, MIM comprises all organizational and processual aspects to fulfill the goals mentioned above [19]. In the following, the manufacturing unit is understood as the entire production network, including all direct and indirect value-adding sub-units like manufacturing, assembly, logistics, planning, and research and development for processes or maintenance.

3.2. Ambidexterity management

Organizational ambidexterity focuses on two fundamental activities that are antagonistic to each other. Nevertheless, they must be pursued simultaneously to ensure competitiveness in the short and long term: exploitation and exploration. [4, 20]

Exploitation refers to applying existing knowledge, while exploration describes the search for new knowledge. More precisely, exploitation uses existing knowledge and skills to generate stable and efficient systems, while exploration generates knowledge that enables organizations to create unique advantages and adapt to changing conditions [21–23].

Concerning the innovator's dilemma, both activities have different understandings depending on the research discipline. In the context of the present paper, the interpretation concerning innovation management is deemed the most relevant. As a result of this, exploitation refers to the creation of incremental innovation, while exploration is understood as the creation of radical innovation.

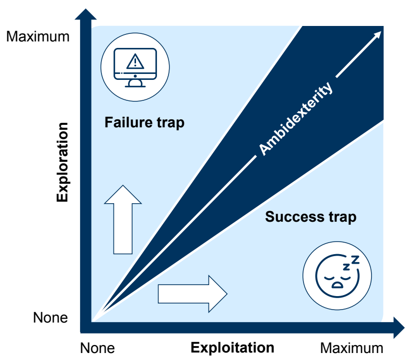

Fig. 1: Risks in the balance of exploration and exploitation

A one-sided focus on either of the two activities is not a feasible option for most manufacturing companies, as this inevitably leads to the so-called success or failure trap (see Figure 1) [24, 16]. The success trap describes challenges resulting from the exclusive focus on efficiency-enhancing exploitation of existing processes. Although incremental innovations based on established success patterns initially help to create a profitability-enhancing effect, this leads to the risk of missing out on long-term transformations caused by radical or disruptive technology changes in the long run. Moreover, an exclusive focus on explorative activities can also have challenging consequences. If disruptive innovations cannot be industrialized profitably, the risk of failing to run an efficient operational business is leading to economic challenges. This effect is defined as the failure trap.

In this context, AM aims to create a balanced state providing sufficient space for exploration and exploitation. Transferred to manufacturing, we define ambidexterity as the ability to deal with the dilemma between operational efficiency and radical or disruptive changes in processes. AM enables manufacturing units to act exploratively and exploitatively to simultaneously produce incremental and radical process innovations for a manufacturing system, ensuring short- and long-term competitiveness [4, 25, 26].

Ambidexterity can be manifested in different ways within the structures of an organization. Scientific literature focuses mainly on three basic approaches [16, 26]: Structural, sequential, and contextual ambidexterity. Structural ambidexterity separates a company into separate units, focusing on partial activities [20]. Exploration and exploitation are thus simultaneously carried out within a dual structure by different employees under specific circumstances adapted to each activity. Sequential ambidexterity proposes an alternating focus shift between the two activities [16]. Exploration and exploitation thus do not take place simultaneously but sequentially. The idea behind contextual ambidexterity is to enable the individual to allocate resources among the different objectives [16]. Thus, contextual ambidexterity is achieved by aligning individuals on a meta-level, which affects all functions and levels of an organization.

According to Raisch et al. [27], several core aspects of AM across all research streams remain unclear or conceptually vague concerning their implementation. In this regard, four central tensions are named, where further research is necessary, to successfully implement organizational ambidexterity: Differentiation & Integration, Individual vs. Organization, Static vs. Dynamic, and Internal vs. External.

The most frequently considered approach to promoting ambidexterity in organizational science is the classification into differentiation and integration. Here, differentiation refers to the separation of exploitative and explorative activities, while integration refers to mechanisms enabling organizations to bring both activities together [27]. Subsequently, it stands out that both are mutually complementary activities that must always be carried out in combination. To summarize, differentiation represents the separated generation of knowledge, while integration ensures the utilization of new knowledge [28, 16, 29].

4. Concept for ambidextrous innovation management in manufacturing

The current approach primarily follows the concept that manufacturing units can achieve ambidexterity using differentiating and integrating organizational design measures.

Organizational design dimensions need to be derived to enable a structured approach, supporting ambidexterity in manufacturing. To do so, the selection in this paper is based on the preliminary work of O'Reilly and Tushman [30], Raisch and Birkinshaw [31], Simsek [32], Güttel & Konlechner [33], Olivan [16], and Schneeberger & Habegger [34]. Commonalities can be identified within the different approaches, and a model of relevant design dimensions for organizational ambidexterity in manufacturing can be aggregated (*Research Clarification*).

To increase the practical understanding and to identify strategies for practical implementation, ten semi-structured interviews were conducted with relevant experts in the field of MIM (*Descriptive Study I*). All involved experts held a top or middle management position with innovation-related responsibilities within manufacturing units from globally operating companies. The interview data was analyzed manually based on transcripts. As a result, organizational design dimensions and concrete implementation measures could be identified. Based on these results, the previously selected design dimensions have been adapted to create an integrated concept for successful AM in manufacturing (*Prescriptive Study*) displayed in Figure 2.

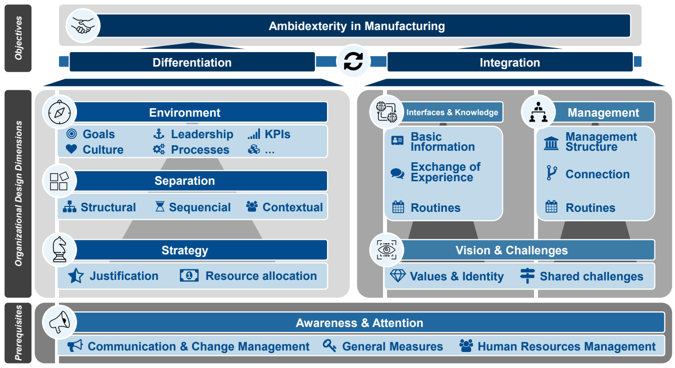

Fig. 2: Organizational design dimensions for ambidexterity management in manufacturing

4.1. Organizational design dimensions and prerequisites

Awareness & Attention for ambidexterity are fundamental prerequisites for successful implementation within manufacturing. Hence, this prerequisite aims to create awareness of ambidexterity's purpose, core principles, contents, and implementation approaches (see Figure 3). Comprehensive awareness includes two aspects. First, awareness for the challenges and opportunities to overcome or realize through AM must be created. Second, the fundamental interrelationships, requirements, and effects of the different types of innovation must be known.

Furthermore, the findings of the *Descriptive Study I* have shown that awareness alone is not sufficient. Additionally, corresponding attention for implementation needs to be promoted among the management. Concerning this, four specific points need to be considered. First, the fundamental will for innovation is necessary. Second, a consensus among managers on the goals of AM in manufacturing is required. Third, it is considered helpful if the managers have previous experience handling ambidextrousness. Lastly, identifying and

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resolving barriers and conflicts within the organization is decisive for successful implementation.

Fig. 3: Design dimension “Awareness and Attention”

Differentiating Strategy forms the basis for all measures that shall have a differentiating effect on the MIM and ensure differentiation acceptance. The aim is to justify both necessary activities and the subsequently implemented separation. In concrete terms, this means that the innovation strategy should contain two parts. The exploitative part focuses on automation and productivity improvements of existing processes. In contrast, the second part should be exploratory and focus on new manufacturing processes and future technologies. Therefore, it is a core component of the approach to state that both parts must be elements of the innovation strategy.

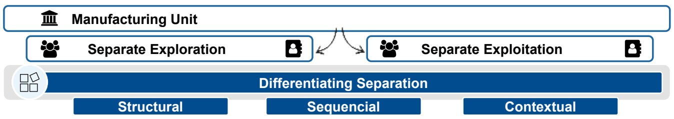

Fig. 4: Design dimension “Differentiating Separation”

Differentiating Separation of explorative and exploitative activities forms a central component, as conflicting goals and mutual interference between the two approaches should be avoided as far as possible (see Figure 4). Separation builds the prerequisite for creating suitable conditions for explorative or exploitative activities for the respective task fulfillment. Furthermore, it ensures a transparent, comprehensible allocation of resources.

The following design dimension aims at setting up the appropriate **Environment** for the respective activity (see Figure 5). These environments or their components should always be coherent in themselves but only loosely coupled to the individual other.

The previously described differentiation makes it possible to meet the requirements of the different environments. In the present approach, it is essential to underline that the appropriate differentiating setting needs to be effectively implemented, as this is decisive to realize the potential of the differentiation.

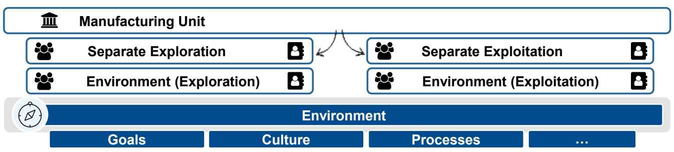

Fig. 5: Design dimension “Environment”

The **Integrative Vision & Challenges** aim to combine exploration and exploitation into a meaningful long-term goal through a basic set of values that are equally applicable to both (see Figure 6). In addition to these values, shared challenges are essential to achieving integration between exploitation and exploration. Accordingly, the design dimension consists of several components, which have to be designed by the organization. These include common identities and values,

Fig. 6: Design dimension “Integrative Vision and Challenges”

common elements of the incentive system, mission statements, and common challenges and objectives.

Integrative Interfaces & Knowledge are necessary as a direct consequence of differentiating measures (see Figure 7). The separated activities need to be reconnected by creating interfaces and exchanging knowledge. As a result of this, networking between the relevant employees via interfaces, coordination between explorative and exploitative activities, and an exchange of knowledge across all hierarchy levels should be ensured. This design dimension focuses on providing an integrative effect at low to medium management levels in particular. In this context, it is crucial to ensure that integration

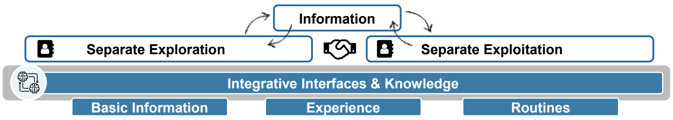

Fig. 7: Design dimension “Integrative Interfaces and Knowledge”

at the employee level can take place directly between employees through a bilateral knowledge flow.

An **Integrative Management** is responsible for implementing integrating effects at higher organizational levels (see Figure 8). Therefore, this dimension has a similar objective as the *Integrative Knowledge & Interfaces* design dimension. However, as the issues to be integrated at higher organizational levels of the company are more complex, volatile, and less delineated, informal instruments between different managers are increasingly necessary.

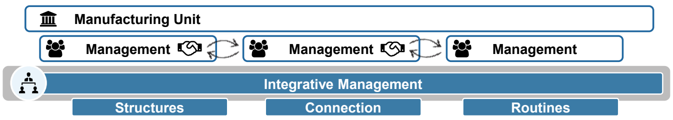

Fig. 8: Design dimension “Integrative Management”

4.2. Managerial implementation measures

After introducing the respective organizational design dimensions, the following section illustrates exemplary manufacturing-specific managerial implementation measures. These enable a targeted influence (differentiation or integration) within MIM and thereby facilitate the implementation of the approach.

Attention & Awareness for AM can be achieved through measures in human resource management, communication and change management, and general measures. For example, an active communication strategy can strengthen attention for ambidexterity by highlighting its relevance in connection with the KPIs of manufacturing (quality, cost, and time) or the EBIT. Regarding human resource management, measures can be taken through targeted competence development programs focusing on innovation management. In addition, a diverse workforce can help to increase awareness for innovation. As a primary measure, companies need to define which innovation activities are considered explorative or exploitative in the manufacturing context to raise employee awareness for the differentiation between the two activities.

To develop a **Differentiating Strategy**, three points have been identified relevant in manufacturing. First, the innovation strategy must show the need for exploitation and exploration and define its contribution to the overall manufacturing strategy. Furthermore, the innovation strategy needs to address conflicting measures and activities to highlight potential conflicts and describe boundaries for both activities. Lastly, a strategy needs to include explorative topics as part of the general objectives to justify the development of radical topics in the manufacturing context.

The present approach uses the three primary alternatives for separation within ambidexterity (structural, sequential, contextual) to implement the **Differentiating Separation**. Structural separation can be achieved in manufacturing by clearly separating functional areas. For example, can operational plants focus on incremental changes while central MIM departments focus more on radical changes. Sequential separation can be implemented through fixed periods for testing activities within the existing manufacturing system. Further, the temporary delegation of employees to the respective other area can help to implement sequential ambidexterity in manufacturing. Contextual separation can be achieved in manufacturing through specific incentive and reward systems, such as innovation awards, and creative environments, such as learning and innovation labs.

The appropriate **Environment** can be attained by designing characteristic elements, which differ depending on whether the environment needs to support explorative or exploitative activities. The following seven elements are relevant to characterize differentiating environments: Strategic goals, fields of action, performance indicators, culture, leadership style, processes or organization, and technology management. Figure 9 provides an overview of how the individual elements can be designed in the manufacturing context

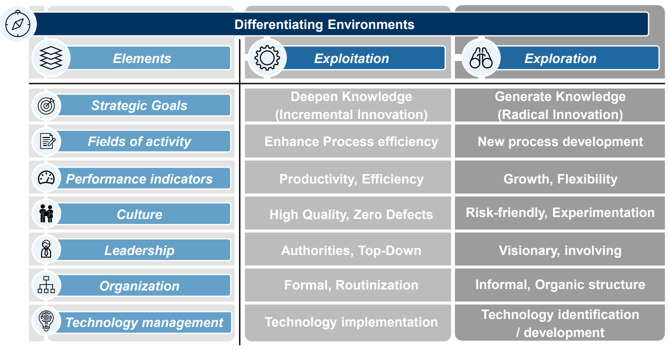

Fig. 9: Overview of elements to create differentiating environments in manufacturing

Several factors can influence the design dimension **Integrative Vision & Challenges**. To achieve a uniform understanding of the shared vision in manufacturing, a shared innovation identity must be developed that unites the incrementally focused values of manufacturing with explorative values. Furthermore, common innovation roadmaps can address future challenges and highlight sequences and interrelations between individual innovation activities.

The design dimension **Integrative Knowledge & Interfaces** measures can be divided into three groups of integration mechanisms. The first group consists of basic information, with a wide range of information but only a little depth of information. The second group, exchange of experience and coordination, tries to reach out to a medium range of information recipients with a medium depth of information. Routines form the last group of integrative measures with a small information width but a high information depth. To share basic information with many recipients, manufacturing-wide-accessible information platforms such as the intranet can be used.

Further, physical or virtual manufacturing-specific event spaces can be utilized to display information. For the exchange of knowledge between specific groups of recipients, realistic manufacturing-specific qualification or simulation environments can demonstrate particular use cases of innovation projects. A routine exchange of information between specific knowledge carriers can be implemented within manufacturing through regular roundtables. These should connect operational employees and specific knowledge carriers from explorative areas to discuss problems and explorative solution approaches.

Within the design dimension of **Integrative Management**, methods can establish a connection between managers and routinize communication within the manufacturing management board. One way to achieve interconnection is to have managers shift between different units with different focus settings (explorative, exploitative). Further, joint conferences on innovation-specific topics can strengthen the interconnection. Routinization of communication can be implemented within the manufacturing management board with the help of regular roundtables on innovation in the manufacturing context.

5. Discussion

Although manufacturing units are regarded as purely exploitative within classical ambidexterity research, it has been shown that this perspective is no longer sufficient for manufacturing companies to stay competitive (*#RQ1*). This paper presents an approach to strengthen AM within manufacturing units through the continuous combination of differentiating and integrating organizational measures (*#RQ2*). To realize these differentiating or integrating effects, seven concrete design dimensions and managerial implementation measures have been identified (*RQ#3*). Significantly, it emerged that measures for the fundamental awareness and attention for AM are necessary within manufacturing to implement AM. An explanation for this is that manufacturing units have been mainly focused on exploitation, and only recent technological developments have created a need for exploration.

In addition to existing approaches, the present approach points out that integrating radical activities into the existing manufacturing system imposes a significant challenge on MIM. Therefore, it was emphasized that the differentiation of

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exploration and exploitation alone is not sufficient to establish AM in manufacturing but that the integration of both activities forms the crucial success factor.

6. Avenues for further research

Further research in the field of ambidexterity in MIM should focus on three specific points. First, the measures to implement the respective effect of the organizational design dimensions in the manufacturing context should be further investigated. This includes not only the completeness of the measures but also the analysis of their respective organizational prerequisites as well as their interdependencies. Second, further research is needed on contextual ambidexterity within manufacturing. Further detailing of the necessary incentive and target systems should strengthen ambidexterity at the individual level within MIM. Third, further research should focus on integrating innovation environments into MIM to implement radical innovation projects successfully and thus strengthen ambidexterity in manufacturing.

7. Summary

This contribution serves as a first approach for AM in manufacturing to cope with the fast development of technologies and a highly complex and turbulent environment. The elaborated approach follows the concept that manufacturing units can achieve ambidexterity by differentiating and integrating exploitative and explorative activities using organizational design measures. Therefore, the relevant organizational design dimensions have been identified, described, and put in a manufacturing context.

Furthermore, an overall concept was developed, which displays the intended effects (integration or differentiation) of the individual dimensions putting them further into a constructive connection. In addition, concrete managerial implementation measures have been elaborated to support the successful implementation of AM in MIM.

The approach is intended as a guidance that depicts what an achievable situation for ambidexterity in manufacturing might look like, revealing tasks that have to be tackled and prompting starting points for further research.

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