Fractal Enterprise Modelling in Strategic Management: Empirical Study in Product Innovation

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Abstract

This paper is a part of an on-going study on the enterprise modelling technique called Fractal Enterprise Modelling (FEM). The overall objective of the research is to enhance business analyses by introducing a more holistic view on enterprise modelling (EM). The idea is to join together the modelling of multiple managerial areas in an organization using one modelling approach, in this case the FEM technique. FEM has already been successfully tested for suitability in diverse business situations. In the presented paper, FEM is used in a real world setting for the modelling of information and knowledge assets to assist management with innovation capability building. The results imply that a fractal technique, such as FEM, is being useful for this task. First, the FEM models produced in the case were promising for the analyses of how the information and knowledge assets are managed when building innovation capability. Second, during the design and analysis of FEM models, the modelling and situational patterns has been distinguished. The generalization of the situational patterns has the possibility to be reuse in similar analyses in other organizations. The results achieved in this study might be viewed as a progress in the implementation of the idea on enhancing holistic modelling using fractal technique. The research followed the design science (DS) methodology.

Keywords

Enterprise modelling, fractal enterprise modelling, FEM, strategy implementation, innovation.

1. Introduction

This paper is a part of the on-going research on the enterprise modelling technique called Fractal Enterprise Modelling (FEM). The overall objective of the research is to enhance holistic business analyses with Enterprise Modelling (EM). In the light of rapid innovation, concauses and multiple effects in the modern business environment, the value traditional application of EM provides is limited due to disjoint modelling domains and emphasis on the top-down modelling practices [1]–[3]. Some researchers argue that the managerial thinking is based around the disciplines and methods that were developed to deal with a world that no longer exists [1]. However, the 'joined up thinking' has not been realized through offering a practical guidance on how to achieve it [4]. Thus, the overall research aim is to raise the questions about how to enhance holistic view within EM.

One of the approaches might be to integrate the system thinking about an enterprise and the fractal view on an organization proposed by [4]. System thinking is distinguished by a fundamental property called holism, i.e., the emergent properties that are meaningful only when are attributed to the whole system [5]. FEM is the example of an artefact realizing a fractal view on an enterprise. It is distinguished by its inherited emphases on the recurring patterns at the progressively smaller scale when constructing a model of the organizational instance. Hence, it should be possible to construct organizational system emphasizing interconnections throughout it in either direction. Analysis of such interconnections may

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help to enhance the visibility and understanding of the emergent properties. Graphically, FEM structure is realized by alternating generic archetypes where the system is built through 'reproduction' of its parts. These archetypes may represent the diverge business domains at different scale. The archetypes are constructed on the basis of process-assets and asserts-process relationships. A process-assets archetype represents the mapping of the assets used in a particular process. The asset-processes archetype shows what processes must be in place for changing a given category of asset. The processes in FEM can be presented at different granularity: from the highest level, where the whole company is presented by one process, to the intermediate level, where the processes can be decomposed to obtain more details. More on FEM building principles can be found in [6].

During the practical application of FEM, extended modelling and situational patterns have been identified (see examples in [7]). A situational pattern refers to the state of the particular business settings discovered during the investigation; whereas, a modelling pattern refers to how this particular business settings may be mapped using FEM. An example of a modelling pattern is the process decomposition constructed on the basis of acquire-asset-stock relationships between process and assets (see explanation in [7]). Initially, this pattern was used for breaking down operational processes into smaller activities on the input-output basis to obtain more details, such as described in [8]. Although, this pattern shares some features with the process decomposition feature of BPMN, there are distinctive differences such as introduction of assets required for the process run (see more in [7], [8]). Further, it has been argued that the process decomposition based on the acquire-asset-stock relationships might be also deployed for modelling at a high level of the system such as organizational Value Chain (VC) including main and support processes. Even in this regard, there is a significant difference between classic VC model of M. Porter [9] and its representation in FEM (for more details, see [10]). Particularly, using FEM makes it possible to distinguish the role a certain support process plays within a main process. This connection is realized through the asset required in the main process which is managed by a certain support process/s. The decomposition of the support processes that manage the asset introduces greater details to the vertical and horizontal interconnections between different elements of the system that may influence the main process's value creation.

The example of using FEM modelling of VC describes the highest level of modelling the organizational system; whiles, using the same modelling pattern in operation analysis describes the intermediate level of the sub-systems. But in order to enhance holistic business analysis, there is a need to understand the functioning of the lowest level of the system (sub-sub-systems) because of they are more complex, i.e., have more elements and interconnections, and more often are subjected to change [5], [11]. Such understanding may help to identify how the emergent properties are built up; hence, improve a holistic business analysis. This paper is concerned with the demonstration of how FEM can be applied to capture the interconnections between elements at the low level of the system to understand what factors may be responsible for the situational state of the organization at a high level. Hence, this study is important for reaching of overall research objective, i.e., to enhance holistic analysis.

The demonstration of how FEM can be used in low-level system analysis, deploys a real case example in capability building for strategic product innovation. The studied organization has recently undergone structural change in order to improve its strategic position of being a technological leader in the high-tech B2B telecommunication industry. The study is resulted in identification of situational and modelling patterns in the case example through mapping the difference in operations before and after the change. Management theories such as aspects supporting organizational learning [12]–[14] and innovation capability building [15], [16] have been used to explain the outcomes.

Thus, the aim of the modelling project is to apply FEM to assist strategic analysis by investigating the low-level of operations. To reach the aim, the mapping of the elements within product development has been focused on innovation capability building through learning. This part of the overall research belongs to the demonstration phase within Design Science (DS) methodology in definition of [17].

The paper is designed in following structure: Section 2 presents theoretical ground; Section 3 provides more details on a business case; Section 4 presents the results; Section 5 lists up the lessons learned; and Section 6 summarizes the research.

2. Theoretical grounds

Since the presented business case (see Section 3) concerns strategic innovation issues where the organizational learning is the integral part, this section provides more insights onto relevant to discussion theories.

To pursue a certain strategy the organization has to change, adjust or enhance strategically important capabilities [15]. [16] argues that organizational capability is an ability to coordinate individual skills and activities. The view is supported by the notion that there is a certain degree of interdependency between activities [18]. The interdependency needs to be managed by coordinating mechanisms to achieve efficiency and effectiveness [19]. The higher the interdependency, the more extensive and complex coordinating mechanism is required [20]. For example, customized products (the matter of business case, see Section 3 'Business case') belong to the high dependency or reciprocal interdependency since the buyers inputs are required in the supplier's processes [19]. Hence, to build a certain capability, the organization has to understand the linkage in the operations that are responsible for coordination of the activities in focus. Since the capability corresponds to an activity in a hierarchical structure, the linkage can be found through breaking up the value creating activities (VC) into strategically relevant segments in order to understand the behavior of costs and the sources of differentiation according to [9], [15].

Furthermore, in a customer-driven environment (as in the presented business case, see Section 3 'Business case') the innovation capability is considered being essential for sustaining performance in high-tech global markets [15]. It can be explained by the fact that the internal mode of operating is driven by a global competition that drives the ability to 'invent' and exploit new markets [21]. Therefore, knowledge creation and continuous organizational learning are articulated as the key resources to sustain the innovation capability as a competitive advantage through differentiation [22], [23]. One of the popular views is proposed by [12]–[14] that define two types of learning: adaptive and generative. The former, adaptive learning, is related to detection and correction of performance gaps to achieve the organizational goals. The latter, generative learning is related to active learning by questioning the assumptions and behavior underlining what has been learned and taken for granted. Putting these two types of learning into organizational practices and routines, the adaptive learning might be associated with the efficiency or operational capability through experience obtained in performing a task or process. The generative learning might be associated with the innovation capability through the differentiation achieved by challenging the ways of applying knowledge to generate new ideas.

It is important to note that both types of learning have to be habitualized and internalized to become powerful [24]. Hence, to support organizational learning, there must be processes in place that allow the exploration and sharing the values and assumptions that underpin how people view the world and acquire new knowledge [25]. Such processes help employees to shed the outdated knowledge as well as learn and deploy new knowledge, thus, helping organization to deliver particular strategies successfully [26]. Apart from the processes that support strategic objectives through organizational learning, that is internalization, there must also be a clear picture shared among members of where organization wants to be and the vision for how it should operate [24]. To address both these aspects, internalization and common vision, requires specific characteristics such as organizational structure and culture that encourage the innovation, continual learning and sharing of knowledge [25]. For instance, what organization's members perceive as 'important' and valid knowledge is shaped by the shared values and norms that govern the acceptable organizational behavior; while, the structure outlines how it should be transferred in a given situation [27]. In a circumstance of the incongruent values, learning may occur but not in a way that furthers the strategic goals [28]

Despite the importance of organizational learning, many theorists warn that it is rather an idealized concept than a practical working model due to the conditions for organizational learning may not exist [29], [30]; and that the focus on organizational learning may absorb more energy and resources than necessary detracting from the core businesses [30]. Nonetheless, the organizational learning should not be dismissed by the organizations operating in the dynamic environment since its elements for success underpin high performance [28]; especially when global competition drives the internal mode of operating to propel the ability to invent and exploit new markets [7]. Thus, learning from both, internal and external environments, at all levels of the organization as well as sharing the knowledge across organizational boarders is considered as one of the most important factors in pursuing innovation strategy [24]. But in pursuing the innovation, the value of the specific skills can be only increased if

organization can effectively capitalize on its bank of expertise, knowledge and experience [28]. Hence, the way an organization sets the boarders in designing its structure may determine the level of effectiveness of such capitalization, thus, strategic goal achievement.

3. Business case

The organization where FEM was applied to assist analysis of organizational change operates in B2B field of Information Communication Technologies (ICT). The global corporation produces and sells test measurement equipment. For number of years, the business has been challenged by the rapidly changing environment and tough competition. As a consequence, the company's position as a technological leader in the field has been compromised. Among the reasons were listed the lack of the common vision and coordinating activities between different functions and departments within product development. Multiple Business Units consist of dedicated R&D teams and Product Marketing. It appears that all of them cooperate with different Sales divisions independently. The result is the inconsistent information coming out to the customers which affects customer relationships. Besides, the inconsistency of the information flow is also actual in the opposite direction, i.e., from customer to the Business Units; as well as between the units. Global customers are managed by the WG1-global account department aiming at serving them in a holistic manner. Prior the change, WG1-Global accounts was the only mechanism that coordinated the activities between Sales and R&D. However, the work was organized in a reactive manner, i.e., oriented on the 'listening to the customers' needs and serve what they ask for'. According to the top management, this is a historical pitfall and such tactics result in a short-term product strategy development that led the corporation to the undesirable, defensive position.

Such dissatisfactory situation forced the top management to pursue a structural adjustment to its R&D department. In particular, a new department, WG1-Technology, was established whose role is to develop a long-term, holistic product strategy. Top management has certain expectations about improvement of strategic position but the change is rather an experiment based on 'gut feeling', i.e., there is lots of confusion on how to approach analysis on the impact of change. The management also emphasized that it is important to have a common understanding of what aspects the change actually is concerned with. Such understanding is considered as important for future decision making and for winning the support from all members in change implementation.

To assist management in this task, the modelling project has been initiated on the basis of mutual benefits. The company was provided with models showing interactions between the company's assets and activities involved in innovation within R&D processes. This mapping may not only enhance common understanding but also shape mind in the decision making. The modelling focus lied on managing the competence necessary for innovation capability building such as information and knowledge. All data obtained in this research is treated with the highest confidentiality to ensure no harm to the organization. The usage of information, risks and benefits are regulated in the consent form signed by both parties.

4. Results of modelling experience

The modelling experience for analysis of strategic change using FEM has resulted in identification of modelling and situational patterns related to the organizational learning through information and knowledge acquisition and usage. The patterns have been extracted from multiple models built for a given business instance.

Fig.1 presents the fragments of decomposition of the processes 'Business development R&D processes' (left side) and 'Product strategy development activities' (right side) at the high level of details. Note, that the original models are presented for the illustrative purpose and better understanding of the generalization basis. For that reason, there is no thorough explanation of the original models. The relevant aspects will be explained more extensively in the Section 4.1 'Modelling patterns and implications.

A modelling pattern emerged when analyzing the linkages useful for constructing of R&D processes related to information and knowledge acquisition and usage. For example, left side of Fig.1 presents

the decomposition of typical business development process belonging to one of the R&D departments (denoted by dashed red boarder). Right side of Fig. 1 presents the decomposition of the product strategy development process performed by the new department. Namely, each activity is associated with the learning through experience acquisition, e.g., 'Experience in feedback analyses' (left side Fig. 1) or 'Experience in technical analyses' (right side Fig. 1). Also, the learning repeats multiple times and is captured through acquisition of intangible asset related to the knowledge and its transfer, e.g., 'Knowledge about requirements and technologies' (left side Fig. 1) or 'Knowledge on present situation' (right side Fig. 1). Hence, these linkages are the part of the construction for both models related to learning in the presented processes. Thus, this construction is useful for illustration the parts of the processes responsible for detection and correction the performance gaps, and for the application of knowledge for generating new ideas; thus, for both adaptive and generative learning respectively.

The situational pattern emerged when analyzing the differences in knowledge acquisition between the two models representing 'before' and 'after' the change. For example, the linkage between experience and knowledge acquisition that is denoted by association link 'resides within' is an important aspect that defines the extraction of the situational pattern. In Fig. 1 (left side) the outside actor, that is, the customer, performs the external analyses and develops product strategy. Hence, it is not before these processes are completed that the information on the future products requirements reaches the R&D department. While, in Fig. 1 (right side) these processes are internalized and moved inside the organization's boarders through the introduction of the new department/workforce whose task is to perform such activities 'in house'. Highlighted in blue, are the participants, such as internal teams and customer, involved in the acquiring of a 'Long-term, holistic product strategy' (asset in dark blue). Hence, the relationships between the internal team and the customer are linked through shared subprocess acquiring this common asset, e.g., strategy development process. Thus, the organizational learning in strategic innovation is achieved through participation in these subprocesses that appropriates the related experience and knowledge in the organization.

The situational pattern is useful for understanding how information and knowledge are managed to enhance organizational learning, hence, innovation capability building [13], [22].

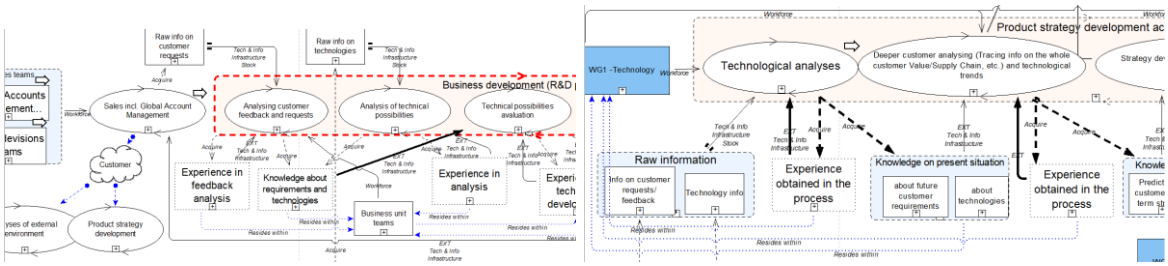

Figure 1: Left side: the decomposition of the typical business development process belonging to one R&D department. Right side: the decomposition of the product strategy development process (fragment from the case study).

4.1. Modelling patterns and implications

The modelling patterns represent a specific set of relationships between processes and assets in FEM. In this case, these are related to information and knowledge assets and their roles in the processes: 'acquire-asset-stock/Tech&Info Infrastructure' and 'acquire-asset-EXT/Tech&Info Infrastructure'.

Acquire-asset-stock/Tech&Info Infrastructure relationships pattern is related to information aspect and is similar to acquire-asset-stock relationships used for process decomposition (see details in [7]). But in the presented case, this pattern is applied to intangible assets such as information or knowledge. Hence, the information plays a double role in the information processing activities as a stock and as a Tech&Info Infrastructure. That means that the information as a stock has to be renewed to trigger the next process run. For example, in Fig. 2 (left side) the 'acquire-asset-stock/Tech&Info Infrastructure' notation is applied to relate the process of information acquisition from the environment to the process of information analysis that uses the acquired information as a stock to produce new knowledge that

can be used in innovation processes (e.g., 'Raw info' asset is used in 'Analysis of external environment' to produce 'Analysis reports' asset).

Acquire-asset-EXT/Tech&Info Infrastructure relationships is related to intangible knowledge aspect. This pattern is used to relate the processes of knowledge creation to the processes of knowledge application. For example, in Fig. 2 (right side) the in-tangible asset 'Knowledge on future trends' is acquired in 'Analysis of external environment' process but is applied in the 'Product strategy development' process. In this configuration, the knowledge is considered as a reusable asset that might be used in any creative processes, i.e., people may find different way of knowledge usage to create value. Since acquire-asset-EXT/Tech&Info Infrastructure relationships pattern is more complex than acquire-asset-stock/Tech&Info Infrastructur, it is described in more details below.

Acquire-asset-EXT/Tech&Info Infrastructure relationships pattern is related to learning which is represented by a double loop (Fig. 2):

Loop1 - acquire-asset-EXT/Tech&Info Infrastructure is a circular relationship element where the relationship between certain asset and the process remains closed, reinforcing each other. For example, this circular element may be referred to a knowledge acquisition through the experience (e.g., 'Experience in strategy development' denoted by dashed rectangle as intangible asset in the process 'Product strategy development', Fig.1) by repeating the routine over again. Hence, the more often the process runs, the better efficiency can be gained in the knowledge creating process. Thus, this way of learning might be associated with detection and correcting performance gaps or adaptive learning in definition of [12]–[14].

Loop 2 - acquire-asset-EXT/Tech&Info Infrastructure as a linear relationship element where the relationship between an asset and a process is determined by passing the knowledge from the process it was created in to the process where it is used in order to create another value. In Fig. 2 (left side) this linear element is referred to the connection between knowledge acquisition, e.g., 'Knowledge on future trends' (denoted by dashed rectangle as intangible asset), and knowledge application by transferring it from knowledge creating process, e.g., 'Analysis of external information' process to the process where it is required such as in 'Product strategy development' process. This type of relationship must be in place to support innovation though acquisition of the unique resources in terms of knowledge. This type of knowledge utilization contributes into strategy implementation through potential to produce know-how and coordination as a source of differentiation. Such utilization of the knowledge implies on the active learning by questioning the assumptions and behavior underlining the traditional ways. Thus, the learning process might be associated with the generative type in definition of [12]–[14].

4.2. Situational patterns and practical implications

The situational pattern in strategic change has emerged by merging the analyses of models produced for the case study and the theories presented in Section 3 'Theoretical grounds'. On the one side, structural design is responsible aspects to enhance organizational learning [27]. Hence, structural design determines whether or not the processes that help organization to deliver innovation strategy successfully such as exploration, learning and deployment of new knowledge [25] will be in place. Since any process or activity is associated with a certain capability building through learning [15], the processes that are included in structural design will imply on whether or not certain capability development is a part of organizational practice. On the other side, the modelling patterns described in Section 4.1 'Modelling patterns and implications', require that both loops must run through the asset of workforce that obtains and possesses the experience and knowledge acquired in the process, e.g., 'Customer' or 'Internal teams' (the association is denoted by dashed arrow 'Resides within' in Fig. 2). Thus, the learning and the application of knowledge and experience may be realized by different parties within or outside the organization, and so the capability building. Hence, the two situational patterns have been identified within product innovation in relation to: 1) the structure that might be associated with adaptive learning; 2) the structure that might be associated with the generative learning.

Two aspects emerged when analyzing the structural change and its impact on the operation while distinguishing the patterns:

- the organizational boarders within knowledge acquisition that outlines what experience and knowledge is acquired, thus, perceived as 'important' [27] in the vertical value chain;

- the coordinating mechanism that outlines how the knowledge is defused/transferred within product innovation departments.

Thus, these patterns define what information will be processed within product development which implies on the organization's view on what experience and knowledge is perceived as important for strategy implementation. Hance, these structural patterns may guide the practitioners in how to use structural aspect to 'shape the behavior of the members' [27] in a way that is instrumental to strategy implementation.

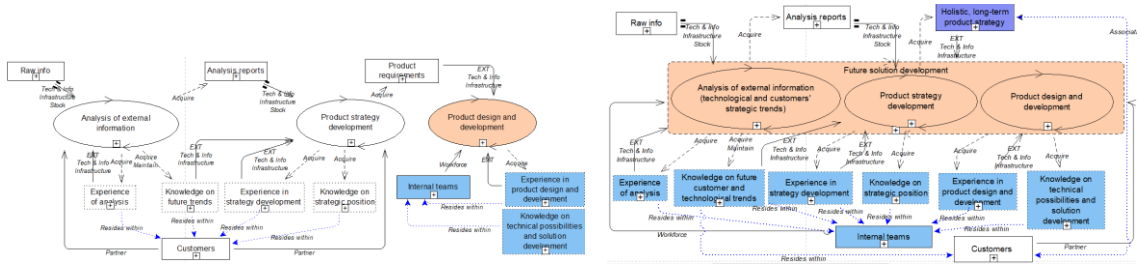

Figure 2: Left side: General pattern for structure associated with adaptive learning in FEM. Right side: General pattern for structure associated with generative learning in FEM (in color processes and assets within the organizational boarders, in blank processes and assets outside organizational boarders).

4.2.1. Aspect of organizational boundaries.

The first aspect, the aspect of organizational boundaries, describes the difference in appropriateness of learning within innovation processes in the vertical value chain of an organization before and after the change.

Before the change, the organization's design of processes does not imply on enhancing organizational learning through external analyses since such processes were 'not in place' [25]. In practice, the external analyses were performed mainly by actors outside the organization such as customers (presumably also by some competitors). In Fig. 2 (left side) processes outside the organization are denoted in black and white; whiles company's processes and assets are marked in pink (processes) and blue (assets) colors. Hence, the learning loops described in Section 4.1 'Modelling patterns and implications' in terms of analytical experience and knowledge acquisition that enhance innovation capability building are also resided outside the organization. This way of working indicates that members perception about how to achieve the goals organization intended rests upon assumption that the customer possesses the valid knowledge about the future solution requirements. Besides, it is expected that the customer himself will transfer such knowledge to the supplier. This implies on that the organization does not question the knowledge underlying new product development transferred from the external actor (such as the customer) but instead detects and corrects the internal, operational knowledge gaps to deliver on the requirements. Hence, this pattern might be associated with the persuasion of the adaptive learning in definition of [12]–[14]. Product design and development process continue perfecting through the internal learning loops described in Section 4.1 'Modelling patterns and implications', implying on building of operational capability through process efficiency [31]. The phenomenon can be explained by the operations being deeply entrenched into organizational routines that is, more likely, developed historically by the cultural norms shaping acceptable organizational behavior as mentioned by [27]. It practically implies that the boarders imposed by the organization in relation to information acquisition and usage, constrain organizational learning. Such constrain is based on the common view about customer needs. It is expected, that the customer himself will communicate the important and valid knowledge necessary for new product development. Consequently, this situation could have been a factor contributing to a weakening position as a technological leader in the industry, described in the case. Such a way of working implies on following the customer, not leading him. This reactive norm of behavior implies on that the organizational culture might be another aspect that compromised the organization's leadership in innovation according to [27]. However, the investigation of cultural aspect is outside of the scope of this paper but the matter of future work.

After the change, the learning from external environment has been internalized by introducing deeper external analyzing activities into the product development process. In Fig. 2 (right side) these activities (previously performed only by the customer, see Fig. 2, left side) are denoted by pink-colored elements. The introduction of the structural change implies on that the organization is willing to questing the knowledge that it has learned from the customer in relation to future products requirements and the established norms of how to behave. These are the attributes of the generative learning according to [12]–[14]. Hence, this situation implies that the internal structural change has been implemented to address the lack of generative learning by moving the organizational boarders into external environment to access extended knowledge base. The structural change complements the well-established old way of working. Consequently, the organization combines the adaptive learning with the generative which is necessary for differentiation through innovation according to [22], [23]. From practical perspective, such situation implies that the strategy implementation through capability building hinges on what is perceived as 'important' knowledge within an organization [27].

4.2.2. Aspect of coordinating mechanism.

The second aspect, the aspect of coordination describes the difference in internal and external coordinating mechanisms within product innovation activities before and after the change. This difference is captured by analysis of the asset that plays a role of instructions and information that guide the product development process, i.e., the EXT/Info related asset. In Fig. 1 (left side) it is denoted by the asset 'Product requirements', in Fig. 1 (right side) by the asset 'Holistic, long-term product strategy'. These assets determine future products' fit with the external context.

Before the change, the 'Product requirements' in Fig.1 (left side) is acquired by the customer in their strategy development processes. The reliance on the input from customer by the R&D teams represents the one-way coordination and implies on serving the market in a re-active manner. Since operational staff lacks a holistic, long vision in their activities it may also imply that all interaction is more likely to happen at the operational level between the multiple teams within development and the sales functions on both sides.

After the change, the coordinating asset at the operational level 'Product requirements (Fig.1, left side) was complemented with the strategically important asset 'Holistic, long-term product strategy' (Fig. 1, right side, dark blue rectangle). This asset represents a common vision that is used as instructions (EXT/Info in FEM notation) in both supplier's internal business development processes 'Future solution development' (marked in red Fig. 1, right side) and in customer strategic business development. Note that customer processes are omitted in this generalization but the linkage is denoted by the association between 'Customer' and 'Holistic, long-term product strategy' assets. In Fig. 1 (right side), the vertical value creation alignment is shown through the internal 'Analyses on technological and customer strategic trends' process that acquires 'Knowledge on future customer and technological trends' asset. Therefore, this asset outlines the clear picture where organization wants to be, the vision for how it should operate and strategic objectives that is one of the main characteristics of organizational learning according to [24]. The two-way communication of a strategic vision and coordination implies on the questioning the information perceived in one-way communication with the external environment that encourage generative learning not only within the organization itself but also at the industry level. Thus, this new asset represents not only the coordinating mechanism that enhances learning from both internal and external environments at all levels of the organization [24] but also reshapes the old norms for what type of knowledge and how must be transferred in a given situation [27]. It introduces the new way of thinking about what is important to know and how to obtain the knowledge required to achieve strategic goals. Presumably, such high scale of organizational learning represents the foundation of the leadership position through innovation. From practical perspective, the implication is that moving the boundaries to enhance external knowledge acquisition entails not only the structural change but also cultural shift necessary for implementing the intended strategy [25], [27].

5. Lessons learned, limitations and future research

The results achieved in the presented study can be interpreted as FEM being promising for modelling and identification of some aspects that could have played a role in organization's ability to enhance innovation capability building to regain leadership. The analyses of these aspects may support practitioners in strategy implementation. These aspects are related to the recognition of the effect the organizational boundaries have on capitalization of knowledge and experience. The structure outlines what skills will be internalized or externalized, thus, determines what capabilities are build or enhanced within or outside the organization. Using FEM, it has been possible to demonstrate the design of organizational boundaries for knowledge creation and usage through mapping the processes and assets performed by different actors.

Analyses of FEM diagrams built for the case example led to the extraction of the modelling and situational patterns that can be useful for the future reuse. Particularly, it has been shown how structural design may influence appropriateness of different types of learning, adaptive and generative (Fig. 2), necessary for innovation capability building. Also, it has been shown what assets are responsible for coordination of the activities within product development processes. The learning aspects have been constructed using specific process-assets relationships notations that composed the modelling patterns: acquire-asset-stock/Tech&Info Infrastructure and acquire-asset-EXT/Tech&Info Infrastructure (see Section 4.1 'Modelling patterns and implications').

Analyses of these relationships pattern suggested that:

- to represent adaptive learning, the circular use of acquire-asset-EXT/Tech&Info Infrastructure relationships is required in FEM to denote the knowledge acquired in the process run that refers to experience and contributes into the process efficiency. Whereas, to represent the generative learning, the linear use of acquire-asset-EXT/Tech&Info Infrastructure is required to denote the knowledge that refers to its reuse and transfer that contributes into acquisition of new knowledge and know-how. Hence, these might be useful in analyses of what organizational elements are responsible for these types of learning;
- by analyzing the linkage to a workforce asset within acquire-asset-EXT/Tech&Info Infrastructure relationships, it was possible to determine what party in the value chain is in possession of learning in terms of experience and knowledge acquisition within industry innovation activities. The practical implication is that it might be useful to review the design of the internal structure and processes in order to internalize learning;
- by analyzing the linkages between knowledge assets denoted by 'EXT/Tech&Info Infrastructure' and the development processes (e.g., 'Product requirements' and 'Holistic, long-terms product strategy', left side Fig. 1), it was possible to identify what knowledge assets responsible for coordination of the activities performed by different actors. The more interconnections exist between such asset and the teams performing the related activities, the more complex the coordinating mechanism is; but also, the better the coherence is within and between the internal and external value creation processes [20]. The practical implication is that when detecting the lack of such linkage it might be useful to review organizational polices to ensure acquisition of the coordinating asset and its transfer among all related parties.

The results of the study have been presented to the participated manager. He expressed that the models were useful as mental maps shaping the mind in the future decisions. It has been pointed out that the patterns attributed to the organizational change helped to understand the situation through the association with the recognized features and smoothening out the complexity. In a given perspective of change, it has become clearer for management what exact aspects and linkage in the operation are responsible for reaching the strategic objectives. Hence, from the practical perspective, the results of this study enhance understanding of what aspects in the low-level sub-system of organizational learning influence strategy implementation. Such understanding may improve holistic analysis for strategic goal achievement through more effective decision-making and prevent (to some extent) the issue of absorption of energy and resources more than necessary when focusing on organizational learning.

The results are limited to the one case study in a particular domain. Due to Covid-19 restrictions it was not possible to proceed the interview sessions with the operational staff of R&D departments. Hence, the results are based on the knowledge, views and perceptions of one senior manager.

There is a need to continue the research looking deeper into the aspects described in this paper. Particularly, to investigate how the holistic product strategy development asset as a coordinating

mechanism can be routinised and rooted into the traditional R&D processes. Such practice could improve the efficiency in organizational learning at all levels. It is desirable to investigate how FEM will perform in analysis of change implementation related to cultural and human aspect. Cultural aspects may explain why generative learning happens, primely, at the centralized level of the organization. Hence, more investigation is needed on this issue. For example, the investigation on: reward system and culture that encourage all employees to ask questions and challenge the current way of working through innovative behavior; performance reviews that are both action and learning oriented; unlearning and reconstruction of the organization's knowledge base aspect; feedback system and training programs that support the change strategies; and the value of learning to balance learning and doing.

The future work of overall research should focus on more empirical trials of building the organizational system from different perspectives. Such experience can generate more knowledge and raise more questions about how to approach holistic business analysis using EM. Of particular importance is to understand how intangible assets are intertwined into physical elements of the modelled system, as well as how they affect the behavior of the system.

It has to be pointed out that the execution is completed by the relatively inexperienced researcher and it is desirable to engage more experts. Also, the modelling work has been performed by the researcher familiar with the FEM toolkit. Hence, the perceived usefulness of the fractal technique might be influenced when used by practitioners themselves. However, the dissemination of the tool among practitioners is desirable.

6. Conclusion

The presented study is a part of the on-going research on fractal enterprise modelling (FEM) with the overall objective to enhance holistic business analyses. The objective is believed reachable, to at least certain extent, through integration of system thinking and fractal view on an enterprise. The presented paper belongs to the demonstration phase within Design Science (DS) methodology. To demonstrate how fractal technique can be used to understand impact of low-level aspects on high-level objectives, FEM has been used in the real settings. The target of the project has been to assist management with the analysis of strategic change in innovation through mapping the transition within product development. The focus has been on modelling and analyses of knowledge acquisition and usage as a constituent part of innovation capability building at a low level of the operations. The results imply that the application of fractal technique for this task can be considered as successful. First, FEM models produced in the case were sufficient for illustrating how information, experience and knowledge acquisition enhance adaptive and generative organizational learning. This has been shown using modelling patterns mapping the processes and assets composing the learning loops associated with the process run. Applying these modelling patterns make it possible to illustrate and explain what parts of the processes comprise the adaptive and generative learning. Second, by using such illustration it has been possible to analyze and identify situational patterns related to organizational boundaries in knowledge acquisition. The patterns have been presented in form of generalized models extracted from the multiple models built for a given business instance. These models make clear how the organizational boundaries can be designed to enhance or inhibit the appropriateness of the information and knowledge required for innovation capability building within the internal and external value chain. Such appropriateness has been associated with the innovation capability through the structural outlines indicating what should be perceived by the members as important knowledge and how to behave when acquiring new information from the external environment. The patterns also illustrate what assets are responsible for coordination of activities within product development and how such assets are acquired. The understanding of these aspects may help practitioners in decision making when managing the innovation capability activities. For instance, awareness of what party in the vertical/horizontal value chain possesses the experience and knowledge that is considered as important for generating future solutions, may direct managers in making organizational design. Also, how individual activities should be coordinated to convert them into organizational capability. Both, modelling and generalized situational patterns, contribute into FEM development by making it possible to reuse them in analyses

of similar situations: either, when detecting a similar situation in the real settings having knowledge about how to represent it graphically; or, when analyzing FEM graphs to identify a similar practical situation.

Considering the outcomes of the presented study, the result might be viewed as a promising in using FEM for analysis of innovation capability building, as well as a progress in implementation of the idea using fractal technique to enhance holistic business analyses.

7. References

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