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Using Fractal Enterprise Modeling in Strategic Analysis with Focus on Intangibles: Empirical Study in Product Innovation

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Abstract. This article presents a new meta-modeling approach for intangible resources. The method combines Enterprise Modeling (EM) and the resource value innovation model from the knowledge management (KM) field. In particular, fractal enterprise modeling (FEM) language has been used for constructing the intangible resources' level of development. The practical application of the proposed method deploys a real case example in the strategic analysis of the organizational change within the product innovation activities. The results imply that the proposed method has a good potential to incorporate the intangibles into EM. First, it has been possible to represent the intangible resources' level of development. Second, the FEM models produced in the study have been useful in the analysis of how tacit knowledge is acquired and appropriated within the organization's strategic capability building. The study resulted in producing modeling and analyzing patterns that can be reused in similar situations. The research followed the Design Science Research (DSR) methodology.

Keywords: Enterprise Modeling, Fractal Enterprise Modeling, FEM, Capability Building, Innovation, Organizational Learning.

1 Introduction

The success of a modern organization no longer relies only on the process efficiency and tangible aspects, such as physical resources, structure, and processes [1]–[3] but incorporates many resources that are intangible, such as knowledge, competencies, learning, capabilities, relationships, organizational culture, etc., [2]–[5]. Moreover, the tangibles diminish in their importance as differentiating factors of competitive advantage [6]–[8], because the intangible resources allow the utilization of other resources more efficiently [9] and have a significant influence on the emergent properties within an organizational system [10]–[13]. Although, the new business reality emphasizes the strategic importance of the intangibles [14]–[17], simply being

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aware of their significance may not be equal to being able to apply them in a particular organizational setting/situation. Managers need more practical tools that help to extract the available knowledge on the intangibles from their organizations. This knowledge should be deconstructed and organized in such a manner that may improve the utilization of the intangibles, e.g., understanding the state, the composition, and the origin of the intangible resources specific to the organization. However, most of the existing, traditional, enterprise models are oriented to capture the visible or tangible aspects of an organization by applying process modeling, goal modeling, role modeling, resource-based view, etc., [18]–[23]. Since intangible organizational resources construct a wide area of a managerial agenda [13], [24]–[26], they should have a larger representation within the enterprise models.

To this point, there are very few studies trying to address the problem of the intangibles' underrepresentation within enterprise models, see examples in [15], [24], [27]–[30]. At present, the intangibles are represented by the generic, well-established conceptual models or frameworks, e.g., resource value hierarchy [31], learning and knowledge models [32]–[34], dynamic capability or change models [35]–[38], etc., and by largely dominating mathematical models (to name a few [10]–[12], [16], [39]–[42]). The mathematical models are oriented on proving and emphasizing the significance and/or impact of the intangibles on the organizational performance; rather than their constituents, configuration, and application that may help to improve the resource management in a given business instance. Also, the conceptual models may be of little practicality for the managers due to their high level of abstraction [43]–[46]. Even though some attempts to incorporate the intangibles in the enterprise modeling (EM) languages exist (see examples in [15], [24], [29], [30]), the field of EM is lagging in modeling of the interconnections between the tangible (such as structure, processes, and physical resources) and the intangible aspects (such as knowledge and experience).

This article is concerned with the usage of EM to represent the interconnections between the intangible aspects, such as tacit knowledge at different organizational levels, and tangible aspects, such as processes and structure. Fractal Enterprise Modeling (FEM) is used for this purpose (more details on FEM are available in in Section 2). This article also provides a demonstration of how fractal representation can be used in the business analysis deploying a real case example in building innovation capabilities. The studied organization has recently undergone a structural change to improve its strategic position in the high-tech business-to-business (B2B) telecommunication industry. The modeling project makes use of FEM by assisting management with the investigation of the low-level processes design concerning strategic goal achievement. Particularly, the analysis focuses on the interconnections between the tangible and the intangible elements at the lower level of the organizational system to understand what factors may be responsible for the strategic state at a higher level of the organization.

Thus, the study aims to propose a meta-modeling method for intangible resources using FEM and to demonstrate how this method can be used in practice. Management theories, such as organizational learning [32], [47], [48], innovative capability building [7], [8], and the resource value innovation framework [31] have been employed for the evaluation and explanation of the outcomes. This research deploys a Design Science Research (DSR) methodology.

The article has the following structure: in Section 2, the short overview of FEM is presented, including its relevance to the problem and solution; in Section 3, the application of the DSR methodology is described; Section 4 provides more details on the business case; in Section 5, the knowledge base of the research is detailed; Section 6 presents the results of the demonstration/evaluation; in Section 7, the results are discussed and the lessons learned are listed; in Section 8, the limitations and the future research plans are outlined; and, in Section 9, the presented research is summarized.

2 Fractal Enterprise Modeling (FEM)

Fractal Enterprise Modeling (FEM) is a modeling method based on a fractal view of an organization. FEM was originally constructed to solve a particular problem: finding all (or to the maximum extent) processes in the organization including invisible ones. In this article, only a short overview of FEM is presented; more on the main principles of building FEM models can be found in [49], [50].

2.1 Short Overview of FEM

The FEM model includes three types of elements: business processes, assets, and relationships between them. A process is graphically represented by an oval, an asset by a rectangle, and a relationship between a process and an asset by an arrow (see Figure 1). A label inside the oval or a rectangle annotates the name of a process or asset respectively. There are two types of relationships in the fractal model. The first is a relationship between a process and an asset showing how an asset is used in a process. In this case, the arrow points from the asset to the process, has a solid line, and is labeled according to the role it plays in the process. The second is a relationship between an asset and a process showing how a process changes an asset. In this case, the arrow points from the process to the asset, has a dashed line, and is labeled to specify the way a process changes an asset. Using these three elements (business processes, assets, and relationships between them) in a recursive manner allows us to build a directed graph.

FEM uses archetypes or patterns of fragments from which a particular FEM model can be built. The FEM model has two generic archetypes or modeling patterns, process-assets and asset-processes. A process-asset pattern shows what resources are needed to run the process (the (a) model in Figure 1). An asset-process pattern shows what processes must be in place to have an asset in the required conditions (the (b) model in Figure 1). This archetype is illustrated in Figure 1 by the red elements showing, e.g., how the workforce asset can be changed by a process of either acquiring, maintaining, or retiring. Thus, the main principle of building the FEM model is realized by alternative application of these two archetypes, in a recursive manner, representing self-similar patterns on different scales, thereby, the term “fractal” is used in the technique. If more details are needed on the process, the process decomposition pattern can be applied (the (c) model in Figure 1). The archetypes in FEM can be applied at the different organizational or system scales, e.g., the archetype can represent a whole organization, which then can be decomposed to obtain more details of the organization, until an individual task is reached, which cannot be decomposed further. More on FEM constructs can be found in [49].

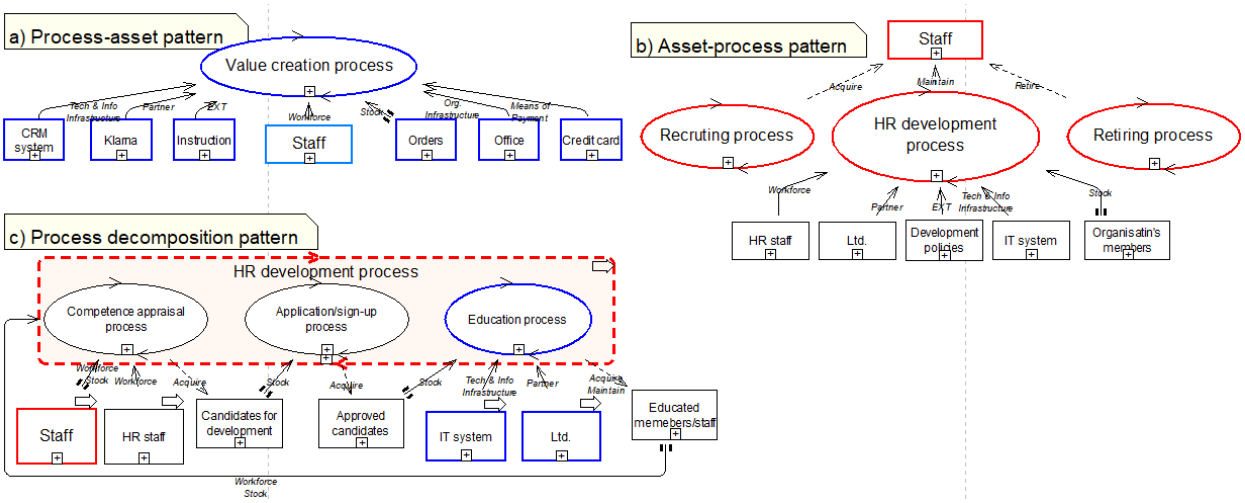

Figure 1. FEM’s generic archetypes (patterns)

To support modelers in adopting the FEM technique, the FEM toolkit has been developed based on the ADOxx platform[†].

2.2 Deploying FEM

This section provides more details on the presented problem and the design of a potential solution for deploying FEM. It also gives some justification for FEM application and suitability for the purpose. Note, that, as the DSR methodology suggests, the design science activities should be combined with the existing knowledge base to ensure rigor in the innovative design solution [51], some researchers question the essence of the rigor aspect within DSR. For instance, [52] and [53] argue that while theories can serve as a source of creative ideas for grounding the design (such as opportunities/problems or existing artifacts/methods), the obligation to ground the research on descriptive theories is unrealistic and even harmful to the field. Thus, in the presented research, the author makes deliberate abstractions from the existing solutions and methods to facilitate innovative and creative thinking. FEM has been chosen, mainly, because of its potential to be applicable for the solution of the problem described in this article. The discussion about FEM's advantages over other possible methods for solving the problem is a matter of the future research.

EM is concerned with the description of the key components of the business to achieve alignment between different areas [5]. Each of the areas has a dedicated modeling technique intending to provide either top-down analysis, such as with goal modeling that breaks down the strategic objectives [54] and roles modeling [55]; or bottom-up, such as business process modeling that describes operational activities [56] and IT infrastructure and service modeling, e.g., as with the ArchiMate language which emphasizes relationships between IT infrastructure and services [57]. However, it has been argued for decades that the disjoint modeling domains produce a fragmented picture of an organizational system which provides poor support for strategic analysis [58]–[60] or neglects to offer business managers the tools to reason about their enterprise design alternatives that improve alignment between strategy, operations, and IT design [15]. Often the top-down models are mainly built with the inputs from the domain experts [15], while the operative level is mostly concerned with the concrete actions, the depiction of which is a complex task [27]. Consequently, the operative business is unfamiliar with the EM models, because an EM language is purposefully designed on a high level of abstraction; hence, the collection of the specific knowledge and experiences from a variety of employees results in a high complexity that cannot be depicted by the EM language [27].

The need for finding ways to enable holistic modeling attracts ever more attention in EM. The majority of the studies refer to the problem of holism in the EM field as to a lack of efficiency in the process of information gathering due to both, the information complexity and the number of sources/stakeholders. Hence, nowadays research is governed by the exploration of the ways to automatize knowledge acquisition during the application of the available EM techniques [15], [27], [28]. However, to address the problem of holism within EM, it is necessary to increase attention to the notion of the intangibles given their growing significance and impact on organizational success [1], [10]–[13], [13], [41], [61]. Yet, there is a very limited spectrum of EM approaches concerning integrating and understanding the intangibles in organizational settings. Even though some examples of the intangibles' incorporation into the EM languages can be found in, e.g., iStar [62], through a combination of the knowledge management (KM) and EM disciplines [15], [24], [29], [30], and simulation techniques to characterize the intangible assets [14], most of the recent research is dominated by measuring the impact of intangibles on the business performance using the mathematical models [10]–[12], [17], [39], [40]. Thus, there is no obvious solution to how to incorporate the intangibles into the business analysis within the existing EM models, e.g., within their hierarchy, components, composition, origin, possession, how they are used and interwoven into the tangible settings, etc. Besides, there is some inconsistency in understanding what

[†] Available at www.fractalmodel.org

intangibles are; therefore, a clearer definition is needed [42]. For instance, the existing theories define intangibles as operant resources, such as tacit knowledge, competencies, capabilities, culture, and relationships [2], [3], [31]. Also, some researchers may consider organizational policies and models as intangibles, consequently, addressing the intangibles' modeling in relation to, potentially, tangible assets (see, e.g., [14]). Moreover, the scarcely existing research also tends to segregate the intangibles categories focusing independently on, e.g., Research and Development (R&D) and learning, human and social capital, technological and informational capital, etc. [63]–[65]. The lack of a holistic view of an enterprise has been also re-confirmed in the previous applications of FEM in the practical settings [66], [67]. Namely, it has been challenging to trace the high-level strategic requirements to the different low-level aspects of an enterprise (such as culture) when modeling for operational decision-making [66].

One way of looking at the problem is to apply a meta-modeling technique [5], [15], [68]–[71]. Furthermore, some researchers argue, that when using the meta-modeling approach of the different viewpoints comprising an enterprise, e.g., goals, processes, business context, information, etc., the capabilities should be an integral part responsible for the whole [5]. This is because the capability is a higher-level component, more strategically oriented, and is useful for the analysis of the effects of change in the business context. Another way is to emphasize the systems view on an enterprise, where different aspects are interwoven in a manner that produces emergent systemic properties [72], [73]. In this case, the potential modeling solution should have the possibility to represent all necessary business elements, both tangible and intangible, at the different scales of an enterprise, and show the interconnections between them, i.e., it should show the enterprise as a system. At the same time, the modeling language should be as simple as possible to fit the conceptual modeling requirements [43], [44].

FEM might be a promising modeling method for considering intangibles because it has both: a conceptual modeling language representing a fractal view of an organization based on the interconnections of the replicated patterns at different scales of the system, and a modeling tool based on the ADOxx platform. FEM uses a very simple language containing only a few basic elements. It is characterized by its inherited emphasis on recurring and interconnected patterns at a progressively smaller scale when constructing a model of an organization consistently and systemically. Thus, it is possible to represent and connect the processes at different levels (where the entire enterprise might be described in terms of the main service which can be decomposed to the level of a single activity at the bottom) and assets of different types (representing different domains, e.g., technical, human, physical resources, etc.). This idea is described in more detail in [74]. Hence, the method integrates system thinking and the fractal view of an organization proposed by [75]. System thinking is characterized by a fundamental property called holism, i.e., the emergent properties that are meaningful only when attributed to the whole system [72]. Analysis of the interconnections in FEM models may help to enhance the understanding of the relevant chains of the relationships across the fractal hierarchy and the emergence of the system properties. For instance, the idea of how the value capture activities can be identified through the interconnections of various aspects for a certain strategy implementation is presented in [76]. Thus, the fractal conceptual approach advances over other methods by providing a homogeneous language to represent multiple business areas that may be expanded or collapsed. FEM's homeostatic property allows changes to be detected at the end of the systemic fractals and indicate the necessity for change and adaption from the bottom-up; or navigate through the system top-down to implement necessary adjustments along the chain of relationships between fractal levels. Hence, the FEM model is seen as a stem to modeling of an enterprise: while, other, perhaps more suitable, techniques can be used for extensions of the branches at a higher granularity. In this way, the proposed fractal concept may enable higher complexity modeling making the requirements traceable to any aspect of the business. Whereas, complexity management can be addressed by the relatively recent visionary development trends in enterprise modeling tools [69], [70], [77], still, there is a need to test the limits of the method, i.e., to understand to what extent FEM can be

representative of the different business areas, and to which ends it is better to deploy the other languages.

This article contributes to a better understanding of how to incorporate the intangible resource modeling within EM deploying the new meta-modeling method that combines the resource Value Innovation model [31] and FEM language. The integration of the resource development hierarchy and the FEM technique advances the meta-modeling idea by the possibility to perform a more enterprise-specific, yet integrated, low-level process analysis. Such analysis may outline the (missing) elements important at high-level processes, i.e., the processes that generate the economic value at the end of a chain.

The result is presented in terms of the patterns distinguished during the practical application of FEM: modeling and analyzing (see examples in [50], [66]). A modeling pattern advises on how to build a model for resource level analysis. An analyzing pattern, e.g., a problem type, refers to a particular area of business analysis. The article also discusses the outcomes of analyzing problem pattern application in a case example.

3 Methodology

The application of the DSR methodology, in general, is described in sub-Section 3.1 and the data collection method is outlined in sub-Section 3.2.

3.1 Application of DSR

The DSR approach is deployed as the main research methodology in this study. The DSR process described by [78] consists of seven iterative steps: identify the problem, define the solution, design, demonstrate, evaluate, and communicate. This article represents the communication step reporting on the results of the designed solution through demonstration and evaluation, i.e., it aims to show how an artifact, the meta-modeling method in this case, may address a practical problem in a given instance [78]. Thus, the presented research contributes to the knowledge generation about the possible alternative solutions to the problem by deploying a particular modeling method, FEM. From the DSR perspective, the application of FEM in the strategic analysis of the presented business situation (Section 6) generates a type of 'missing' knowledge [51] about the possibilities of the proposed method to support business analysis for the purpose. Also, to find the missing knowledge, it is useful to carry out the research using existing knowledge because it gives the extent of the missing knowledge and the challenges faced in filling the gap [51]. FEM has already been tested in multiple case studies (see examples in [66], [67], [74], [79], [80]) to investigate its modeling and analytical suitability in various business situations. Although the results have been promising, the quality of the analysis has encountered the issue of modeling integrity or holism. This includes the conceptual and methodological limitations associated with the modeling of intangible resources. Because the emergent properties assigned to the systemic holism are based on the interconnections between such resources [72], this work is dedicated to addressing this limitation.

The new knowledge, obtained in this work, enables the innovative design which calls for research that will fill the knowledge gaps necessary for creating a novel design [81]. The new design concerns the conceptual methods deploying a meta-modeling for intangible resources using FEM. Thus, more precisely, this article is aiming at improving the knowledge about the solution (meta-model) to the stated problem as discussed in Section 2. This new knowledge adds to the knowledge base that extends the theories and methods, which is the key outcome in the DSR [52], [53].

The innovation part of the conceptual method demonstrated in this article is based on two features: the existing theories about the intangible resources conceptualization, and the combination of the intangibles conceptualization and the fractal modeling technique, i.e., merging the existing intangible resource hierarchical concepts with the FEM language (the details are

presented in Section 6). Thus, the design step in the DSR produces an artifact in the form of tangible knowledge about the new method of modeling and analyzing the organizational intangible resources by combining a fractal view of an organization and the value added or resource hierarchy model.

During the application of the proposed method in real business settings, the demonstration and evaluation steps are performed simultaneously. The demonstration uses examples from the modeling project involving a high-tech organization. In this project, FEM has been applied in the investigation of the different business issues on multiple occasions. The evaluation is embedded in the demonstration process [78]. The demonstration step in DSR requires effective knowledge of how to use the tested artifact to solve a specific problem [78]; while the evaluation step requires assumptions (or hypotheses) about the performance [51], [78]. The presented demonstration has used the knowledge on FEM usage available at the moment. However, the additional knowledge, obtained during the construction of the FEM models/patterns, is new knowledge that is fed back into the evaluation and/or the next cycle of re-design or finding a solution to the given problem. The evaluation has generated new insights about the design suitability and/or how to use FEM for the purpose. Note, that the evaluation in DSR contradicts the positivistic interpretation of the results. Positivism either confirms or contradicts the hypothesis. But the results of the presented FEM study neither confirm nor contradict an assumption or hypothesis. Both negative and positive outcomes are accepted and treated as new knowledge outlining future development and ideas. The acquired knowledge represents the results of the evaluation in the form of lessons learned about the new method. The generated new type of knowledge might be useful for future iterations by (a) understanding how fractal technique may enhance the existing resource modeling, (b) providing insights into how FEM's modeling language can be improved for the purpose, and (c) generating new possibilities for FEM application for the future research directions.

The main requirement for the evaluation of FEM for the presented purpose is the possibility to represent the value added resource development concept [12] and its usefulness in the business analysis. Because the knowledge obtained in this work may belong to either the inner or outer environmental layer in relation to FEM application for the purpose, the behavior of the artifact is constrained by both. The outer environment is the set of external forces acting on the artifact; whereas, the inner environment is the set of components and relationships between them that construct the artifact [81]. Thus, future innovation may find a more suitable environment to improve FEM performance and/or adjust FEM's design as a concept and/or as a software tool.

3.2 Data Collection Method

Within a DSR process, several research strategies and methods for data collection and data analysis can be used. The research strategy used for the demonstration in this research is a case study. The case study has been chosen because it is associated with the framework for the synergy of rigorous and relevant research of emerging phenomena within DSR, according to [82], [83]. Thus, the relevance of the presented research is addressed through the contextual application of FEM. The advantage of a case study is in the triangulation of data sources that elevates the understanding of a particular business instance, thus, increasing the validity of analysis [84]. However, case studies are criticized for the "impossible-to-precisely-pin-down-knowledge" [51, p. 128]. This methodological weakness produces biases in the knowledge generation and its analysis and, therefore, the results may be questioned.

The main data source in the project has been the interviews with the senior manager in the case organization. The semi-structured interview form has been chosen to ensure that the obtained data is relevant to the research question, simultaneously encouraging the participant to express their opinions that they may find relevant to the topic [82], [84].

Mixed methods of data collection, e.g., multiple interviews and observation, could have been beneficial in the study but were not applied. The observation bypasses the biases associated with the interviews where the reliability of the collected data relies on the experience, interpretations,

and knowledge, as well as encounter memory glitches of the participants [82], [84]. However, the observation introduces another drawback such as the effect of the observer on the observed, lack of trust, additional cost, etc., [85], [86]. Hence, as the mixed methods entailed unproportionally larger costs than the improvement of the data quality, in this case they were dismissed.

4 The Situation Faced in the Business Case

This section presents a short description of the business case. More details can be found in the previous work where the same data is used [50], [66].

The organization, where FEM was applied to assist in the strategic analysis of organizational change, operates in the B2B field of Information and Communication Technologies (ICT). The global corporation produces and sells test measurement equipment. For several years, the business has been challenged by the rapidly changing environment and tough competition. Consequently, the company's position as a technological leader in the field has been compromised. Among the reasons are listed the lack of a common vision and coordinating activities between different functions and departments within the product development.

Multiple Business Units consist of dedicated R&D teams and Product Marketing. All of them cooperate with different Sales divisions independently. This results in the inconsistent information provided to the customers which affects customer relationships. Moreover, the work was organized in a reactive manner, i.e., oriented on 'listening to the customers' needs and serving what they ask for. For instance, the customers may have contact with the different sales departments or business units when communicating their needs. Hence, each of the business units tries to address the needs but these actions are not coordinated among them. According to the interviewed management, this was a historical pitfall and such tactics resulted in a short-term product strategy development that led the corporation to an undesirable, defensive position.

Such a dissatisfactory situation forced the top management to pursue a structural adjustment to its R&D department. In particular, a new department, the Technological Advisory team, has been established. Its role is to develop a long-term, holistic product strategy and to enhance the collaboration between different departments. The top management has a certain expectation about the improvement of the strategic position, however, this change is rather an experiment based on 'gut feeling', i.e., there is much confusion about how to conduct a strategic analysis of the impact of the change. The management also emphasized that it is important to have a common understanding of what aspects the change is concerned with in operations that may influence the positive outcome.

To assist management in this task, the modeling project has been initiated based on mutual benefits. The company has been provided with models showing interactions between the company's assets and activities involved in innovation within R&D processes. The modeling focus has been on managing the competencies necessary for innovation capability building based on information and knowledge.

All data obtained in this research project 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.

5 Knowledge Base

The business case briefly presented in Section 4 concerns strategic innovation issues where organizational learning is an integral part. This section provides more insights into relevant strategic analysis theories that control the modeling direction, i.e., what aspects and why should be visualized in the models. In particular, the learning characteristics provide the basis for analysis of how different types of knowledge, acquired and used at the lowest level, influence organizational capability building. To approach such analysis using modeling, the resources and the interconnections underlying learning as well as the resource development stages must be

visualized. The resource management theories are deployed to provide the basis for the categorization of the resources and to describe their development using modeling. The adjustment of the categorization to the FEM language is also described.

5.1 Innovation and Organizational Learning

In a customer-driven environment (as in the business case presented Section 4) the innovation capability is essential for sustaining performance in high-tech global markets [8]. It can be explained by the fact that the internal mode of operating is driven by global competition that, in turn, drives the ability to 'invent' and exploit new markets [87]. Therefore, knowledge creation and continuous organizational learning are articulated as the key resources to sustain the innovation capability as a competitive advantage through differentiation [47], [88]. One of the popular views is proposed by [32], [47], [48]. The researchers define two types of learning: adaptive and generative. The former is related to the detection and correction of performance gaps to achieve organizational goals. The latter 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 for the modeling purpose, adaptive learning might be associated with the efficiency or operational capability through the experience obtained in performing a task or process [33]. Generative learning might be associated with the innovation capability through the differentiation achieved by challenging the ways of applying the knowledge to generate new ideas [33].

It is important to note that both types of learning have to be habitualized and internalized to become powerful [89]. The social perspective on learning inextricably connects the learning process to the organizational context and involves the interconnections and shared understandings within and between multiple work groups [46], [90], [91]. Hence, to support organizational learning, there must be processes in place that allow the exploration and sharing of the values and assumptions that underpin how people view the world and acquire new knowledge [92]. Such processes help employees to shed the outdated knowledge as well as learn and deploy new knowledge, thus, helping the organization to deliver particular strategies successfully [4]. 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 the organization wants to be and the vision for how it should operate [89]. To address both these aspects (internalization and common vision) specific mechanisms such as organizational structure and culture are required to encourage innovation, continual learning, and sharing of knowledge and coordination [92]. However, the higher the level of organizational complexity, the more sophisticated mechanisms are needed [93]. For instance, what an 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 [4]. The intra and inter-organizational interdependency, collaboration, and synergy/coordination arise from the ability to share knowledge, availability of the human capital resources, technologies, vision, etc. [7]. In circumstances of incongruent values, learning may occur but not in a way that furthers strategic goals [7].

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 [94], [95]; and that the focus on organizational learning may absorb more energy and resources than necessary detracting from the core businesses [95]. Nonetheless, organizational learning should not be dismissed by the organizations operating in the dynamic environment since its elements for success underpin high performance [7]; especially when global competition drives the internal mode of operating to propel the ability to invent and exploit new markets [8]. Thus, learning from both, internal and external environments, at all levels of the organization, as well as sharing knowledge across organizational borders, is considered one of the most important factors in pursuing an innovation strategy [89]. But in pursuing innovation, the value of the specific skills

can be only increased if the organization can effectively capitalize on its bank of expertise, knowledge, and experience [7]. Hence, the way an organization sets the borders in designing its structure may determine the level of effectiveness of such capitalization and, thus, strategic goal achievement.

5.2 Value Innovation Concept in Resource Management

To proceed with the modeling for capability building through learning, it is necessary to have a clear understanding of the terms used within the human resource management discipline. However, there is no common agreement among researchers, nor understanding among management on what terms like resources, assets, capability, and competence mean. For instance, [31] uses the term 'core competence' as the ultimate level of resource building capacity, while [37] uses the term 'core capability' rather than competence and emphasizes that capability evolves slowly through collective learning and information sharing. Similarly, the terms 'resource' and 'asset' are used interchangeably but distinguished by being strategically important or critical vs non-strategically important [96]–[98]. Value Innovation approach has been deployed for terms standardization in this work.

Value Innovation focuses on the internal capabilities that evolve from adding value at each layer of human resource usage [31]. This concept is a useful way to organize and categorize such terms and can be associated with the imaginary steps as a continuum of increasing value and difficulty along the ladder (see Figure 2). At the bottom of the ladder, the author places the resources, i.e., the building blocks of competencies made up of tangible, intangible, and human assets. These assets represent the inputs into the value chain. Capabilities are on the next rung of the ladder and are captured within functional areas. These assets denote a company's ability to exploit its resources and represent different processes and routines that coordinate the flow and exchange of resources. Competencies, on the next rung, provide a cross-functional integration and coordination of capabilities, while, on the top of the ladder are the core competencies, i.e., the collection of competencies that are widespread in the organization according to [33]. Adding value at each rung implies higher complexity which is more difficult to replicate. Thus, the higher the resource on the resource rung, the more valuable it is for the organization. Hence, such resources represent a stronger potential for building a strategic competitive advantage.

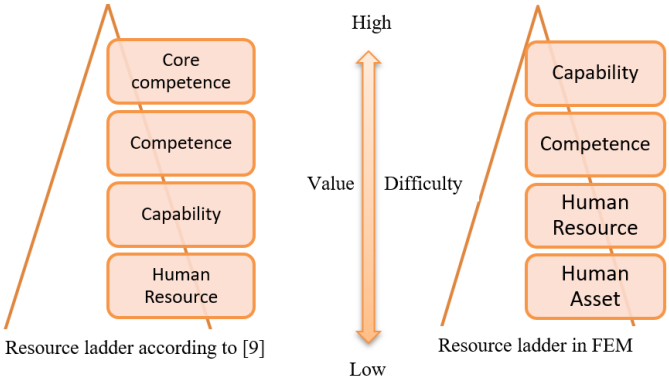

Figure 2. Value Innovation ladder (left side – resource ladder adapted from [31]; right side – adapted to FEM logic)

5.3 Value Innovation Concept Adapted to FEM

The fractal modeling technique may be efficient in drawing and exploring how "value from the level below resulting in increased value added as the organization works up the system and exploiting the resources, skills, knowledge, and capabilities that each level offers" [31, p. 94]. It is believed that the combination of the Value Innovation Model and FEM benefits the strategic analysis by providing the possibility for the explicit creation of the links between the

organizational layers in resource development. However, it is important to describe the choices made during the modeling for resource development based on the Value Innovation Model (Figure 2, left side). These choices concern the terminological differences that must be addressed.

First, in [31] the author uses the term 'resource' as an underlying building block of the ladder; while in FEM the term 'workforce' is used to denote a human type of asset, i.e., the asset with a 'workforce' notation is treated as a basic human resource input that is necessary to run the process. This asset may take any name such as 'employee', 'person', etc. The basic workforce assets and the human resources in FEM can be distinguished when there is some value added to the human asset after which it can be promoted to the resource level. The evaluation may deploy any available technique for this purpose as a complement to FEM, e.g., the VRIS model, based on the argument that a firm that possesses valuable (V) and rare (R) resources has the potential to gain competitive advantage, and when such resources in addition are imperfectly imitable (I) and non-substitutable (S), the resources have the potential of building sustained competitive advantage [99] (see more on this topic in [76]).

Second, the ultimate level of the ladder proposed by [31] is the core competencies which is the collection of widely spread competencies within the organization. In other sources [37], researchers use the term 'core capabilities' instead, as a fundamentally important attribute of the organization's strategy; where 'capability' is defined as the integration and reconfiguration of internal and external organizational skills, resources, and functional competencies to match the changing environment [100]. Still, the authors often use the terms competence and capability interchangeably. For instance, [31] uses the term 'competence' and [37] uses the term 'capability'; while other sources [7] assume it is irrelevant which term is used 'capabilities' or 'competencies', important is that it represents the 'core', i.e., the essence of the firm. In the logic of this article the term 'capability' is used as the ultimate complexity layer. For that reason, the continuum of organizational capabilities developed by [31] has been modified. Particularly, the resources layers have been adjusted to represent the ladder as 'Human asset'-'Human resources'-'Competencies'-'Capabilities', respectively (see Figure 2, right side). Following the logic of [31], the sequence represents the ladder at the bottom of which is the human assets. In the FEM notation, the human asset is denoted by the relation named 'Workforce' in the process-asset archetype (see Figure 1 (a)). The asset can be transformed into a resource by adding value to it through certain activities; as mentioned above, the asset becomes a resource if it can be identified as firm-specific. The ability within functional areas or departments (marketing, production, etc.) to exploit, coordinate, and exchange resources represents competence, whereas integration and coordination of cross-functional (or cross-departmental) competencies represent the capability.

Specific elements are introduced in the FEM notation to denote Value Innovation elements. Below, the theoretical grounds about how the main elements within the Value Innovation framework may be represented in FEM are discussed.

Human Asset – asset acquisition is the first stage of the value adding activities in capability development. In FEM tangible assets or resources are denoted by a rectangle with a solid border, intangible – by a rectangle with a dashed board, and human – by a rectangle with a solid border (but with the notation 'Workforce'). Thus, the generic Acquire-Asset pattern can be used to denote human asset acquisition in FEM. For instance, a hiring process acquires a human asset to perform a certain task.

Human Resource – in the definition of [8], 'resource' is a productive asset owned by a firm. It distinguishes three types of resources: tangible, intangible, and human. However, in the definition of [101], resources are not only productive assets but firm-specific, i.e., meaning that they are difficult if not impossible to imitate, e.g., trade secrets, certain specialized production facilities, and engineering experience. Such assets are difficult to transfer among firms because of their transaction and transfer costs, as well as because they may contain tacit knowledge. Since only critical to strategy implementation human assets need to be developed, not all processes are designed to add value to human assets, i.e., often assets are simply used in the processes. To describe the human resource in FEM, the intangible assets, such as knowledge and experience, are

acquired in a strategically important process and must be connected to a human asset with the notation ‘resides within’. To denote firm-specific assets or resources, a text description and a different color scale can be used in FEM (see more on how to use FEM to identify firm-specific assets in [76]).

Competence – characterized by superior functionality, i.e., the best use and coordination of skills and abilities to perform tasks within one function or department [101]. In FEM, the pattern of tacit knowledge reuse (e.g., Acquire-Asset-EXT/Info&Tech Infrastructure) describes the process of gaining competence through routinizing, i.e., learning and applying the knowledge and experience in each process run.

Capability – can be associated with any activity and as the activities follow the hierarchical structure, so do the capabilities [8]. The capabilities are as tightly connected to the development of resources as competencies since individual resources do not confer competitive advantage; they must work together to create organizational competence and capability [8]. It is important to note that both terms (competencies and capabilities) can be applied at the individual level, i.e., assigned to a person; or at the organizational level, i.e., assigned to the organizational unit, function, or the whole organization. This distinguishment is essential for the analysis of the resource building capacity, hence, to the work presented in this article. In FEM, the organizational capability might be shown by connections of the multiple assets, denoted with ‘Workforce’, ‘Partner’, or ‘Beneficiary’, to the same process implying the need for information share and coordination between multiple participants. Thus, the potential for capability building may be identified; while the individual ‘Workforce’ asset connected to the process denotes the potential for HR resource development. Such representation merely shows what processes enable certain capability development without recognition of whether the capability is well or poorly developed in the organization.

How this logic of resource management can be deployed in modeling with FEM is presented in Section 6.1.1.

6 Results of the Modeling Project

The modeling for analysis of the capability building in product innovation using FEM has resulted in the extraction of several patterns, both modeling and situational. These patterns describe how the information and knowledge are acquired and used. As mentioned in the introduction, a situational pattern refers to the state of the particular business settings discovered during the investigation; whereas a modeling pattern refers to how these particular business settings may be represented using FEM.

The modeling pattern emerged when analyzing the linkages useful for constructing the R&D processes related to information and knowledge acquisition and usage. Each activity has been associated with learning through knowledge and experience acquisition and reuse in the same activity, e.g., ‘Experience in analysis’ (Figure 3). As the process repeats multiple times, it results in the acquisition of another intangible asset which is used in the next activity, e.g., ‘Knowledge of future customer and technological trends’ (Figure 3). Hence, this construction is useful for the illustration of the parts of the processes that are responsible for the detection and the correction of the performance gaps, as well as for the application of knowledge for generation of the new ideas for 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 structural change. For instance, the linkage between experience and knowledge acquisition that is denoted by the association link ‘resides within’ is an important aspect that defines the extraction of the situational pattern. In Figure 4, the outside actor, that is, the customer, performs the external analysis and develops product strategy. Hence, it is not before these processes are completed, that the information on the future product requirements reaches the R&D department. In Figure 5 these processes are internalized and moved inside the organization’s borders by 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 customers, involved in the acquiring of a 'Long-term, holistic product strategy' (an asset in magenta). Hence, the relationships between the internal team and the customer are linked through a shared subprocess acquiring this common asset, e.g., the strategy development process. Thus, organizational learning in strategic innovation is achieved through participation in these subprocesses, i.e., appropriating 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 and, hence, innovation capability building [13], [22].

6.1 Practical Implications from the Case Example

This part of the article presents more details on how tacit knowledge modeling has been approached to denote human resources, competencies, and capabilities, and provides more insights into the practical use of the method in strategic analysis for capability building.

6.1.1 Applying the Value Innovation Concept in the Real Case Example

Having in mind the description of the transformation processes from assets to capability, FEM models have been built for the investigation of the real situation. The analytical logic of the meta-modeling method, proposed in this article, is explained in one of the models' examples.

Figure 3 presents a model extraction of the organizational product development activities at the generic level. On the right side, the 'Strategic product innovation' process is depicted as a group of comprising processes performed by different R&D & Marketing units (denoted as a group of assets in light blue 'Unit 1' … 'Unit 5' with 'Workforce' notation). The outcome of these processes is 'Future solutions' (the asset highlighted in purple). On the left side, the processes performed by the new department 'Technology Advisory team' are depicted as the asset in a beige rectangle. The processes are shown in pink as ovals within the decomposition group of the main process 'Industry analysis process'. The tangible assets are denoted by solid-line rectangles (e.g., 'Raw info' or 'Analysis report'), while the intangible assets – by the dashed-line rectangles (e.g., 'Experience in analysis' or 'Long-term customer relationships'). Before the change, the innovation process of product development would be constituted only by the processes shown on the right side of Figure 3, i.e., performed by multiple R&D and Marketing teams. This situation implies that the experience and knowledge in industry analysis have not been appropriated within the organization's human resources. Hence, the strategic resource building capacity based on which a competitive advantage can be achieved has not been fully exploited. Arguably, that situation could have been one of the explanations for the compromised strategic position.

The first transformation, according to the Value Innovation concept, concerns the acquisition of the assets required in a particular process. For instance, the workforce needs to be hired to run the processes in an organization, e.g., 'Technology advisory team' or 'Raw info' (in Figure 3) has to be obtained from the external environment to be used as a stock asset/input into the analytical processes (these acquiring processes are omitted in the graph). These assets do not yet represent any competitive advantage, i.e., any firm has access to such assets. However, they can be developed into strategic resources by adding a certain value through internal processes and routines.

The second transformation, according to the Value Innovation concept, concerns the development of a strategically important resource based on an asset. In the case example, the transformation of the asset to resource can be observed multiple times. Two types of such transformation can be distinguished:

- The first type of transformation is related to the acquisition of the intangible resource through tangible inputs. An example of the first type might be human resource development. The experience and the knowledge in performing the tasks contribute to the development of the unique personal abilities and skills transforming the worker into a unique human resource. In

Figure 3, this is shown through the participation of the 'Technology advisory team' in the process of 'Product strategy development' (denoted by the pink oval) and associated connections to intangible experience and knowledge assets (denoted by the blue rectangles).

- The second type of transformation is related to the development of tangible resources through intangible inputs. The example of the second type of transformation can be observed in acquiring intangible resources such as 'Long-term customer relationships' through various tangible interactions between the firm and the customer. In Figure 3, this is shown through customer participation in the internal process of 'Product strategy development' and association link to the 'Long-term holistic product strategy' asset (denoted by the blue rectangle). This linkage implies the underlying trustworthy customer relationships necessary to acquire this strategically important resource.

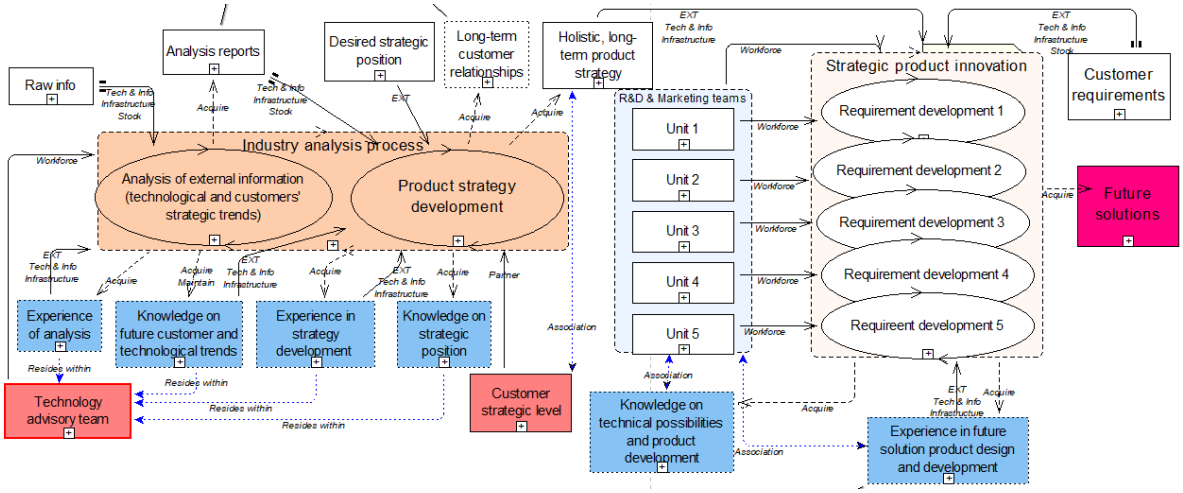

Figure 3. General FEM model for product innovation process (case example)

The third transformation, according to the Value Innovation concept, concerns development of the competence based on resources. Since organizational competence is related to the coordination of the activities within the team or department, the transformation from resource to organizational competence can be observed regarding the technology advisory team. In particular, in both processes presented in Figure 3, 'Analysis of external environment' and 'Product strategy development', the asset 'Technology advisory team' denotes the group of members. Each member gains accumulated experience and knowledge about how to perform the activities in cooperation with other participants in the team. This, of course, happens primarily at the individual level (asset to resource development) with the following accumulation of experiences and knowledge at the group level. The transformation from resource to organizational competence can also be observed regarding the multiple R&D product units that must work coordinated within each team to deliver on a particular customer requirement. As described in the case context, such competence is present in the organization since all the teams manage to deliver high-quality solutions to the customers' requests.

The fourth transformation, according to the Value Innovation concept, concerns the development of organizational capability based on competence. Since organizational capability is the coordination between the multiple functions and departments, the capability building is identified twice in the case example at the abstract level of the strategic product innovation process:

- The first occurrence is related to the process of 'Strategic product innovation' (see Figure 3), where multiple internal R&D units are involved to acquire a 'Future solution' asset. The coordination is enabled by the asset 'Holistic, long-term product strategy'. Through this asset, the control of the holistic approach to the development of the customer requirements (assigned to different R&D units) is enabled. This implies capability building in strategic product development because the coordination of the experience and knowledge between different teams and functions is increased.

- The second occurrence is related to the process of ‘Product strategy development’, where multiple actors, such as the internal strategic team ‘Technology advisory’ and the customer’s strategic team, cooperate to develop mutually beneficial ‘Holistic, long-term product strategy’ (Figure 3). However, such a strategy can be obtained only based on the trusted relationships between the partners. Hence, the ‘Long-term customer relationships’ asset, obtained in this process, is a firm-specific resource and is a prerequisite to the holistic product strategy. The activities of the firm’s and the customer’s strategy development are coordinated by their visions for the desired future strategic positions of each actor, whereas the cooperation may reinforce its achievement. This capability is related to relationship building, i.e., the alliance at the early stage of the emerging markets, and is an ultimately desirable situation to secure a future leadership position for both.

6.1.2 Generalization of the Modeling Patterns

The modeling practices derived from the models built for the real case, such as those illustrated in Figure 3, have been generalized into the modeling patterns that can be reused in a similar analysis using FEM.

Figure 4 represents a common FEM process-asset pattern. This pattern shows what assets are used in the process to acquire another asset (more details are available in [50]). Both assets, ‘HR staff’ and ‘Employee’, correspond to the first resource layer, since none is firm-specific yet, i.e., any firm may obtain the same assets. Hence, the process is not a value capture (i.e., does not concern the resource transformation) but a generic value creation (i.e., task oriented) transforming the inputs into the outputs. The process is controlled by the explicit instructions outlining the activities flow. If the organization puts the flow into the firm’s context, it may become firm-specific (i.e., strategic resource).

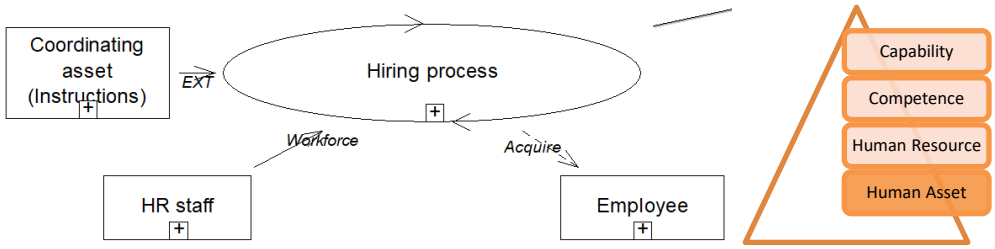

Figure 4. Asset-to-Asset pattern

Figure 5 and Figure 6 illustrate how the transformation of the asset-to-resource can be depicted. Figure 5 illustrates the transformation of a tacit asset into a tangible resource, e.g., ‘Human resource’.

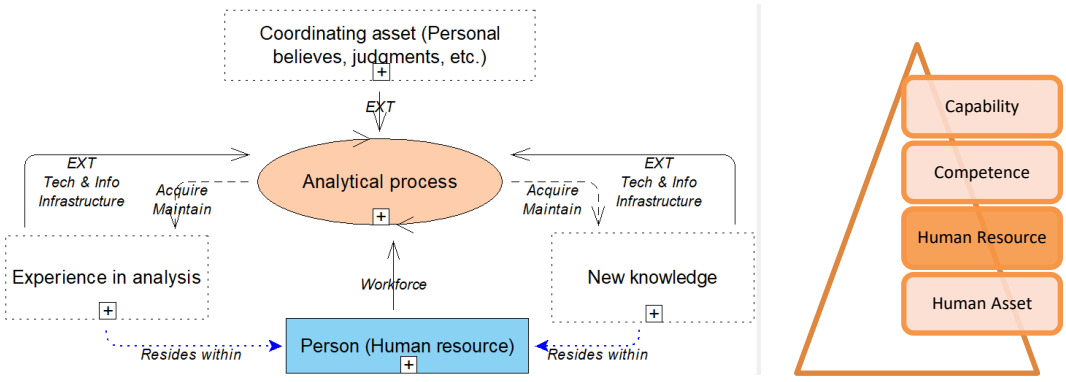

Figure 5. Tacit asset-to-tangible resource pattern

Figure 5 shows the ‘Analytical process’ from the perspective of workforce value. The person may become a resource to the firm when he/she possesses the knowledge, skills, and experience needed to achieve a better quality of the process outcomes. Personal beliefs, judgments, values, etc., control the process run. With time, the value added to the human asset through the multiple process runs elevates both, the human value as a resource and the quality of the process outcomes (e.g., the outcome of analysis). This, in turn, creates a differentiation based on which the organization may reach its strategic objectives. However, at this stage, the abilities and skills are resided within a person. Hence, the analysis process builds personal competence. This competence may be an instrument for organizational goal achievement, but it is not sustainable yet. Other routines and processes are required to internalize such competencies, i.e., to transform them into organizational competence.

Figure 6 depicts the process in which a tangible asset may be transformed into an intangible resource, e.g., ‘Long-term customer relationships’.

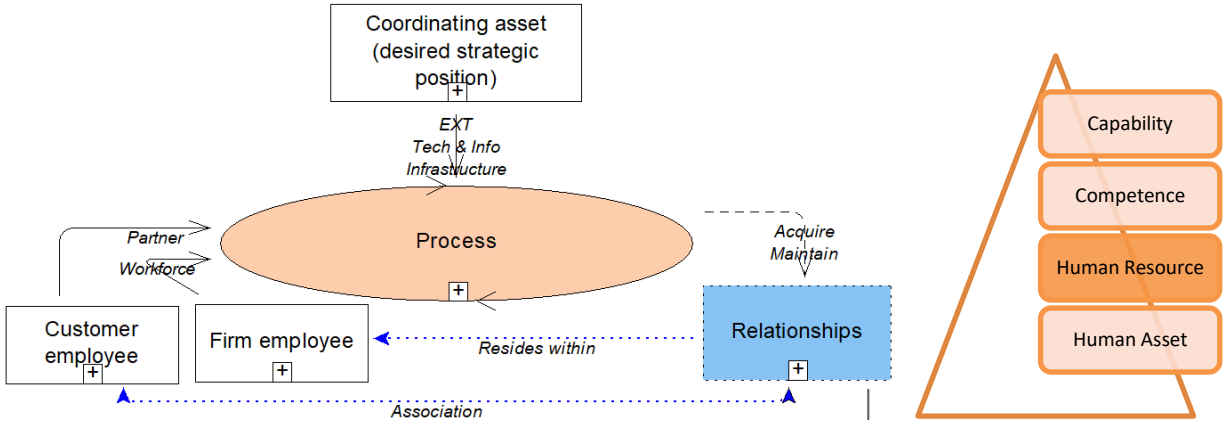

Figure 6. Tangible asset-to-intangible resource pattern

Figure 6 shows that a ‘Process’ transforms a tangible asset (e.g., ‘Customer employee’) into a resource (e.g., ‘Relationships’). Since this process requires the interaction of the two parties (the customer and the firm), the outcome is the relationship acquisition. To succeed in such development requires control and coordination based on the understanding and sharing of the desired strategic positions of the participants. Even though this asset may represent a unique resource, it is still possessed by an employee and is not yet firm-specific.

Figure 7 depicts the resource-to-organizational competence transformation pattern. This pattern denotes the process that converts personal skills and abilities into organizational competence. The individual knowledge and experience contribution to the common task acquires the group knowledge and experience. By performing the common tasks in a ‘Process’ (denoted by an oval in pink) within a team (denoted as a group asset in blue rectangle comprising multiple team members), the group of people learns how to coordinate and cooperate while creating a new product. Hence, the asset ‘Team’s knowledge on how to cooperate’ (denoted as an intangible asset by a dashed-line rectangle) represents the organizational value in terms of organizational competence, since individual knowledge and experiences (HR resource) are worth less outside the team borders, i.e., as individual. To succeed in such development requires coordinating asset that ensures a common understanding and sharing of customer requirements. However, because such coordination happens only within one team, it is not yet an organizational capability but an organizational competence in a particular function.

Figure 8 denotes the competence-to-capability pattern. This pattern shows that the organizational competencies, that are resided within the different internal functions/teams (experience and knowledge in the process), must be combined in a coordinated way to achieve a common goal. Thus, the coordinating asset represents the highest scope of the organizational activities, e.g., ‘Organizational strategy’.

The model in Figure 9 is another example of the competence-to-capability pattern representation. This pattern shows that the organizational competence that resides within the internal teams, such as experience and knowledge in the process, is combined with the other actor's similar resources (e.g., customer). Hence, the 'Process' represents a process in which the organizational competencies may be transformed into the organizational capability. In this example, there is also a need to coordinate the activities at the highest level of the organizational activities, e.g., the desired strategic position.

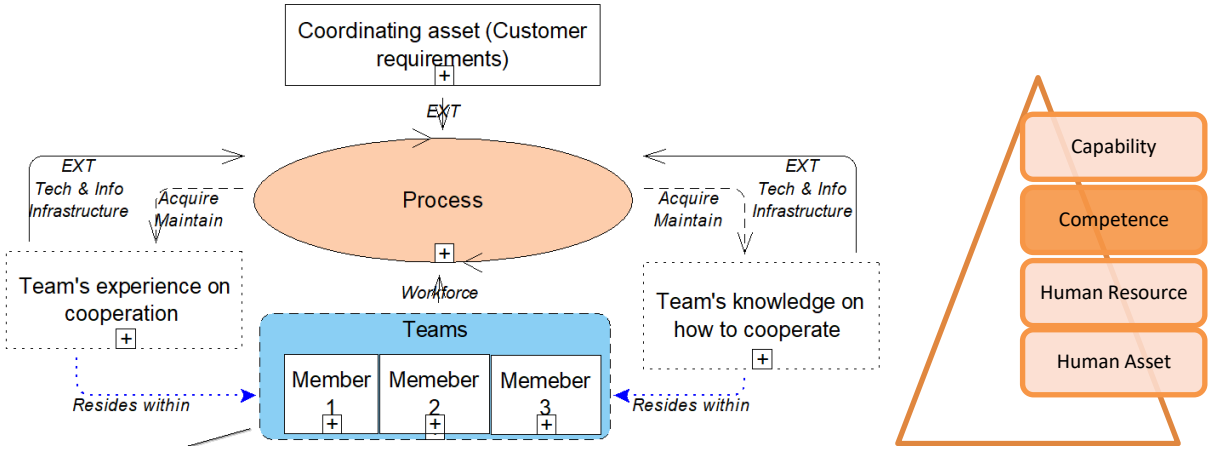

Figure 7. Resource-to-organizational competence pattern

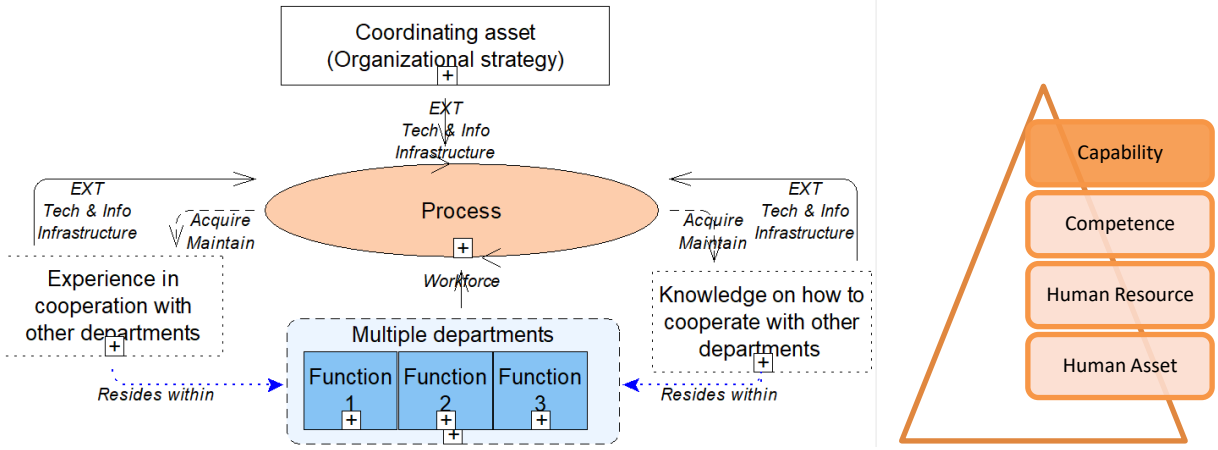

Figure 8. Organizational competence-to-organizational capability resource pattern

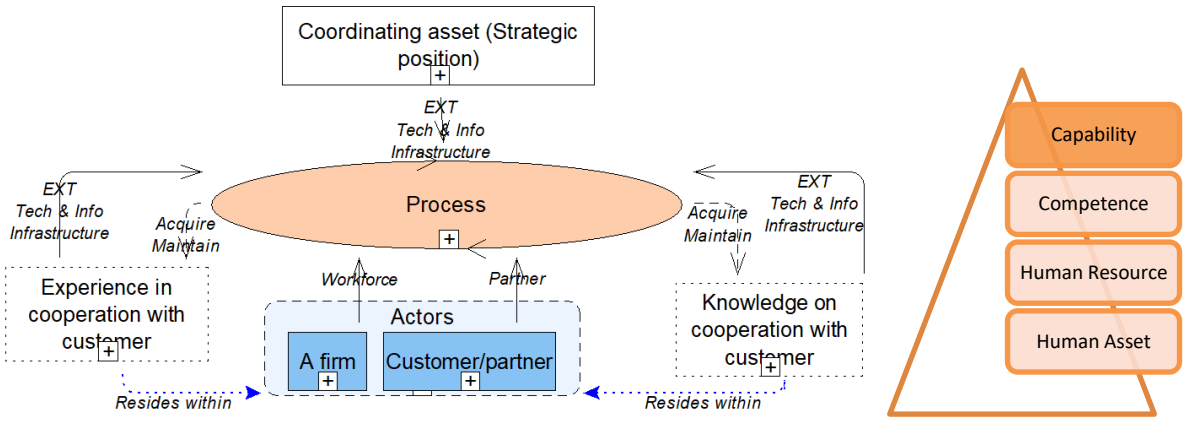

Figure 9. Organizational competence-to-organizational capability resource pattern

6.1.3 Patterns Notations and Learning Implications

The modeling of human resources represents a specific set of relationships between the processes and the tangible and the intangible assets in FEM models. The intangible assets are related to the information and the knowledge possessed by the tangible (human) assets. This possession is annotated by the 'Resides within' relation. Also, it is important what role an intangible plays in the process. To indicate how an intangible is used in the process, the two sets of relations can be used: 'Acquire-asset-*stock*/Tech&Info Infrastructure' and 'Acquire-asset-*EXT*/Tech&Info Infrastructure'.

The 'Acquire-asset-stock/Tech&Info Infrastructure' relationship is related to the information aspect and is similar to the 'Acquire-asset-stock' relationship used for the process decomposition (see details in [50]). 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. In the case example, in Figure 10 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; whereas the process of information analysis uses the acquired information as a stock to produce new knowledge that can be used in the innovation processes (e.g., 'Raw info' asset is used in 'Analysis of external environment' to produce 'Analysis reports' asset).

The 'Acquire-asset-EXT/Tech&Info Infrastructure' relationship is related to the intangible knowledge aspect. This linkage is used to relate the processes of knowledge creation to the processes of knowledge application. In the case example, in Figure 11 the intangible asset 'Knowledge on future trends' is acquired in the 'Analysis of external environment' process but is applied in the 'Product strategy development' process. In this configuration, knowledge is considered a reusable asset that might be used in any creative process, i.e., people may find a different way of the knowledge usage to create value.

The 'Acquire-asset-EXT/Tech&Info Infrastructure' relationship may describe both types of learning described by [32], [47], [48], i.e., adaptive and generative learning.

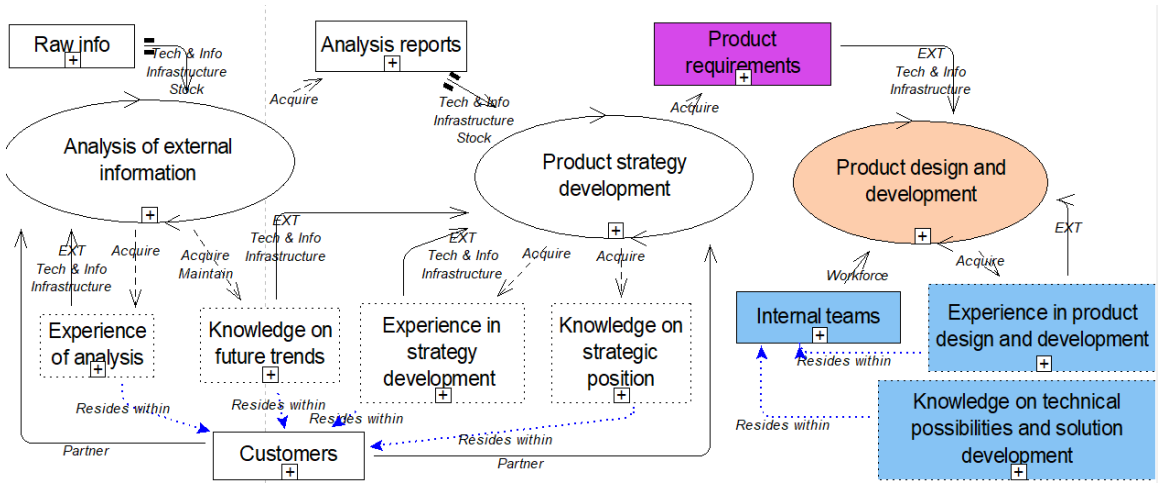

Figure 10. The general pattern for building organizational competence which may be associated with adaptive learning (in color − processes and assets within the organizational borders, in blank − processes and assets outside organizational borders)

Adaptive learning is represented by the 'Acquire-asset-EXT/Tech&Info Infrastructure' relationships in a circular manner, i.e., the relationship between a certain asset and a process remains closed, showing that resources are reinforcing each other. For instance, this circular element may be referred to as knowledge acquisition through experience (e.g., 'Experience in strategy development' denoted by a dashed rectangle as an intangible asset in the process 'Product strategy development' in Figure 10 and Figure 11) by repeating the routine several times. Hence,

the more often the process runs, the better the efficiency gained in the knowledge creating process. Thus, this way of learning might be associated with the detection and the correcting of performance gaps or adaptive learning in the definition of [32], [47], [48].

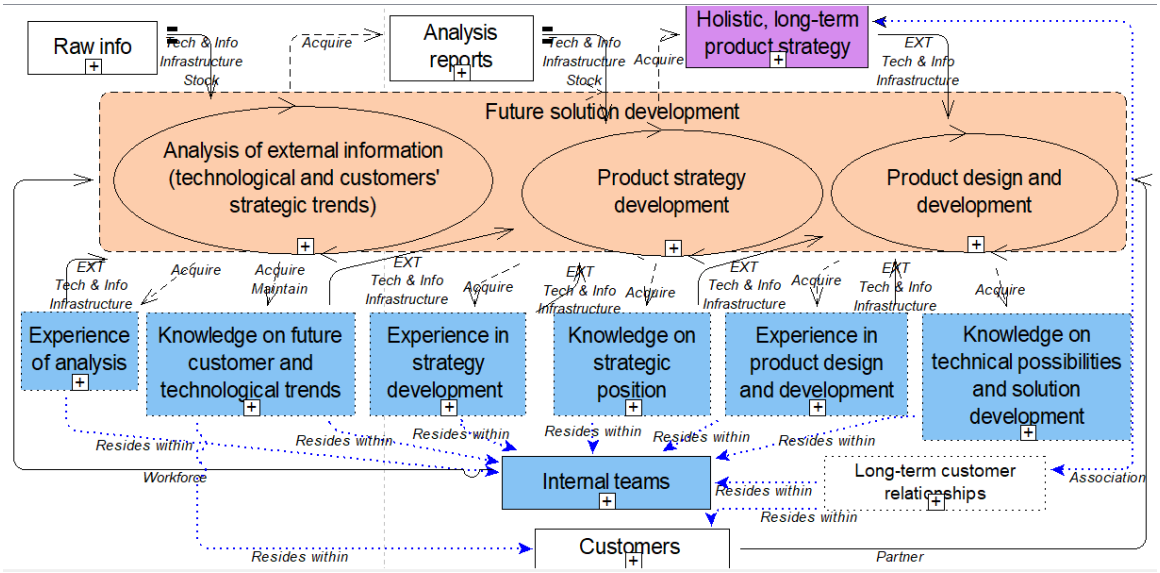

Figure 11. The general pattern for building the organizational capability which may be associated with generative learning (in color − processes and assets within the organizational borders, in blank − processes and assets outside organizational borders)

The generative learning is represented by the 'Acquire-asset-EXT/Tech&Info Infrastructure' in a linear manner, i.e., where the relationship between an asset and a process is determined by passing the knowledge from the process it was created into the process it is used to create another value. In Figure 10 and Figure 11, this linear element is referred to by the connection between knowledge acquisition, e.g., 'Knowledge on future trends' (denoted by a dashed rectangle as an 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 'Product strategy development' process. This type of relationship must be in place to support innovation through the acquisition of unique resources in terms of knowledge. This type of knowledge utilization contributes to the strategy implementation through the potential to produce know-how and coordination as a source of differentiation. Such utilization of knowledge implies active learning by questioning the assumptions and the behavior underlining the traditional ways. Thus, the learning process might be associated with the generative type of learning as defined in [32], [47], [48].

6.2 Problem Pattern and Practical Implications

The problem patterns in the strategic change (illustrated in Figure 10 and Figure 11) have emerged by merging the results of the analysis of the models produced for the case study and the theories discussed in Section 5. On the one hand, the structural design is a responsible aspect for enhancement of the organizational learning [4]. Hence, a structural design determines whether or not the processes that help the organization to deliver the innovation strategy successfully, such as exploration, learning, and deployment of new knowledge [92], will be in place. Since any process or activity is associated with a certain capability building through learning [8], the processes that are included in the structural design determine what capabilities will be a part of the organizational practice. The modeling guidelines described in Section 6.1 require both learning loops running through the asset of the workforce (within or outside the organization). The workforce obtains and possesses the experience and the knowledge acquired in the process, e.g., 'Customer' or 'Internal

teams' (the association is denoted by the dashed arrow 'Resides within' in Figure 10 and Figure 11). Thus, the relationships between the different participants in the processes, within or outside the organization, determine whether the learning (i.e., as a process of the coordinating activities) is available to the organization or only the learning outcomes (i.e., as ready-to-use processed information). Hence, the problem patterns identified within the product innovation are related to the impediments in the transformation of the organizational competence to the organizational capability resource level. The solution in the case example has been found through the structural change that triggered the transformation by enhancement of learning. Thus, the patterns are related to:

- The structure that might be associated with adaptive learning.
- The structure that might be associated with generative learning.

These patterns define what information will be processed within the product development process, and imply what experience and knowledge are perceived as important for the strategy implementation in the organization's view. Hence, these structural patterns may guide the practitioners in how to use structural aspects to 'shape the behavior of the members' [4] in a way that is instrumental to strategic goal achievement.

The two aspects emerged while distinguishing the patterns presented in Fig. 10 and Fig. 11. Their practical implications are described in the remainder of this section.

6.2.1 Aspect of the Organizational Boundaries

The aspect of the organizational boundaries describes the difference in the appropriateness of the learning within the innovation processes before and after the change.

Before the change, the organization's design of processes did not imply enhancing organizational learning through external analysis since such processes were 'not in place' [92]. In practice, the external analysis was performed mainly by the actors outside the organization, such as customers (presumably also by some competitors). In Figure 10 and Figure 11, the processes outside the organization are denoted in black and white, while the company's processes and assets are marked in pink (processes) and blue (assets). Hence, the learning loops that enhance innovation capability building also reside outside the organization. This way of working indicates that the members' perception, e.g., about how to achieve the goals the organization intended to achieve, rests upon the assumption that the customer possesses valid knowledge about the future solution requirements. Besides, it is expected that the customer himself must transfer such knowledge to the organization. This implies that the organization does not question the knowledge underlying new product development transferred from the external actor (such as the customer). Instead, the organization tends merely to detect and correct the internal operational knowledge gaps about customer information. Hence, this pattern might be associated with the persuasion of adaptive learning in the definition of [32], [47], [48]. The product design and development process continues perfecting through the internal learning loops; which implies building the operational capability through process efficiency [102]. The phenomenon can be explained by the operational routines being deeply entrenched into the cultural norms that historically shape acceptable organizational behavior as mentioned by [4]. It also implies that the organization's borders impact organizational learning by constraining information acquisition and usage. Such constraints are based on the common view about the customer needs, such as 'customer knows best'. Namely, it is expected that the customer himself will communicate the important and valid knowledge necessary for the new product development. Consequently, this situation could have been a factor contributing to a weakening position as a technological leader in the industry, as described in the case. Such a way of working indicates that the organization follows the customer trends and is not actively leading. Such norms of behavior may be a product of the organizational culture that compromises the organization's leadership in innovation according to [4]. However, the investigation of the cultural aspect is outside of the scope of this article and is a matter of future research.

After the change, the learning from the external environment has been internalized by introducing deeper external analyzing activities into the product development process. In Figure 11 these activities (previously performed only by the customer, see Figure 10) are denoted by pink-colored elements. The introduction of structural change implies the organizational will to quest the incoming customer knowledge and to establish the new behavioral norms; which are the attributes of the generative learning according to [32], [47], [48]. Hence, this situation implies that the structure is being used to address the lack of generative learning. By extending the organizational borders, the organization has created access to a wider range of the knowledge base. As this structural change complements the well-established old way of working, the organization combines adaptive and generative learning; which is necessary for differentiation through innovation according to [47], [103]. Such practice captures the phenomenon of strategy implementation through what is perceived as the 'important' knowledge within an organization in product development [4].

6.2.2 Aspect of the Coordinating Asset

The aspect of the coordination describes the difference in the explicit internal and external coordinating assets before and after the change. This difference is captured by the 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 Figure 10 it is denoted by the asset 'Product requirements', and in Figure 11 by the asset 'Holistic, long-term product strategy'. These assets control the future products' fit with the external context.

Before the change, the 'Product requirements' in Figure 10 are acquired by the customer in their strategy development processes. The reliance on the input from the customer by the R&D teams represents one-way coordination and implies reactively serving the market. Since operational staff lacks a holistic, long vision in their activities, it also indicates that the interaction, more likely, happens at the operational level on both sides.

After the change, the coordinating asset at the operational level 'Product requirements' (Figure 10) has been complemented with the strategically important asset 'Holistic, long-term product strategy' (Figure 11, magenta rectangle). This asset represents a common vision that is used as instructions (EXT/IT&Info Infrastructure in FEM notation) in both, the supplier's internal business development processes 'Future solution development' (marked in beige in Figure 11) and in customer strategic business development. The 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 Figure 11, the vertical value creation alignment is shown through the internal 'Analysis on technological and customer strategic trends' process that acquires 'Knowledge on future customer and technological trends' asset. Therefore, this asset outlines a clear picture of where the organization wants to be, the vision for how it should operate, and the strategic objectives. These are the main characteristics of organizational learning according to [89]. This early customer involvement ensures the two-way communication of a strategic vision and coordination and implies the questioning of the information perceived in the one-way communication. 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 [89] but also reshapes the old norms for what type of knowledge and how must be transferred in a given situation [4]. Hence, it introduces a new way of thinking about what is important to know and how to obtain the knowledge required to achieve strategic goals. From the practical perspective, the acquisition of the high-level coordinating asset captures the phenomenon of how the structural change, intended to enhance the external analysis, also entails the cultural shift necessary for implementing the intended strategy [4], [89].

7 Discussion and Lessons Learned

This study aims to propose a meta-modeling method for intangible resources using FEM and to provide a practical demonstration of how such representation can be used in business analysis. The aim has been reached through the application of FEM in the business analysis of the strategic change using a real-world example. In doing so, three theoretical elements have been deployed: (1) the resource hierarchy [31] has been used as a conceptual frame to represent the intangible resources using the FEM technique, (2) organizational learning [32], [47], [48], and (3) innovative capability building [7], [8] for analyses of the outcomes.

The achieved results can be interpreted as positive meaning that the proposed meta-modeling is a promising approach to represent and analyze the intangibles' level of development within an organization. Namely, by using this approach, it has been possible to identify the aspects in the business settings influencing the organizational learning approach, i.e., adaptive and generative learning. In particular, it has been demonstrated how the capitalization of the knowledge and the experience can be analyzed, e.g., by investigating the organizational process design and the process control assets. Thus, the method obtained in this study, extends the knowledge base about the fractal technique's possibilities for modeling intangible resources in two ways, as a modeling tool and as an analytical tool.

The following lessons can be learned from the FEM application as a modeling tool:

- The existing conceptual and graphical notations, i.e., asset, process, and relationships between them, sufficiently cover the query to represent the intangible resource rung in the hierarchy [31]. Whereas, the textual description provides more details on the assets and the processes, e.g., the process name may describe the organization's focus on a desired competence and/or capability development activities.
- Although there is no specific graphical notation in FEM to represent strategically important resources, the usage of different colors in combination with the text might be sufficient for the task. For instance, the asset playing the role of 'Workforce' may represent both, a worker performing a task that is not strategically important for an organization and a worker whose task is strategically important. Therefore, it is desirable to develop the latter into a human resource, but it may require value adding activities and investments. Similarly, the process notation may represent a basic activity/process or strategically important competence and capability since any activity can be associated with a competence or capability (see Figures 10 and 11).
- The level of the intangible resource building within an organization is recognized through a human asset 'Workforce'. This asset indicates whether a competence or a capability is appropriated to the person, the team, the department, or the whole organization. For instance, in Figure 5 the competence in a process is possessed by a person representing the personal ability to exploit intangible resources, such as information, experience, etc. Furthermore, in Figure 8, organizational competence emerges through the accumulation and exchange of personal knowledge and information between the team members of a particular department or function. Likewise, in Figure 9, the organizational capability is denoted by the asset group 'Workforce' representing a cross-functional or cross-organizational integration of the personal knowledge, skills, and experience.
- The level of the resource in the hierarchy is also recognized through the linkage between the coordinating asset and the 'Workforce' asset; whereas, different colors or textual descriptions are helpful for the notation of the explicit coordinating asset. The identification of the resource level hierarchy might be useful for finding missing elements that enhance coordination and for understanding the process's purpose and design. For instance, on the personal level, it might be personal values, beliefs, cultural norms, etc., that direct the process of analysis (see Figure 5). Similarly, 'The long-term product strategy' directs the interaction, negotiation, and decision-making between the different parties in Figure 11.

- The learning aspects have been constructed using the specific process-assets relationship notations that may be associated with the different types of learning: 'Acquire-asset-stock/Tech&Info Infrastructure' and 'Acquire-asset-EXT/Tech&Info Infrastructure' (see Section 6.1.3). Analysis of these relationships suggests the following usage of the FEM notations for the task:
  - To represent adaptive learning, the circular use of the 'Acquire-asset-EXT/Tech&Info Infrastructure' relationships is required when using FEM. These relationships denote the knowledge acquisition in a process referring to a specific knowledge and experience that contribute to the process efficiency. On the other hand, to represent generative learning, the linear use of 'Acquire-asset-EXT/Tech&Info Infrastructure' is required. These relationships denote the knowledge reuse and transfer which, in turn, contributes to the acquisition of new knowledge and know-how. The practical implication is that the modeling can help to analyze how different types of learning emerge in the organization;
  - By analyzing the linkage to a workforce asset within the 'Acquire-asset-EXT/Tech&Info Infrastructure" relationships, it has been possible to determine the party within the innovation activities that possess the learning, such as experience and knowledge. The practical implication is that it might be useful to review the design of the internal structure and the processes to internalize the learning.
  - By analyzing the linkages between the knowledge assets denoted by 'EXT/Tech&Info Infrastructure' and the development processes (e.g., 'Product requirements' and 'Holistic, long-term product strategy', Figure 10 and Figure 11), it has been possible to identify the knowledge assets responsible for the coordination of the activities performed by the different actors. The more interconnections exist between such assets and the teams performing the related activities, the more complex the coordinating mechanism it represents, but the better the coherence is within and between the internal and external value creation processes [20]. The practical implication is that when the lack of such linkage is detected, it might be useful to review the organizational policies to ensure the acquisition of the coordinating asset and its transfer among all related parties.

About the application of the proposed meta-modeling method as a tool in the strategic analysis, the following knowledge has been obtained:

- The proposed meta-modeling approach makes it possible to describe the position of the assets on the resource development rung [31] through the visualization of the interconnections between the activities, the involved parties, and the coordinating asset. The understanding of such a position can be useful in the analysis of the entire organizational system. For instance, the more parties are involved in the process, the more sophisticated coordinating mechanism is required [93]; hence, it becomes more difficult to develop and/or replicate the coordinating asset. In the case example, the pro-active way of working in R&D has been achieved by the creation of the mutually beneficial coordinating asset for both parties, the customer and the firm – the asset 'Holistic, long-term product strategy' (see Figure 11). This asset can be obtained only through the prompting the relationships with the key customers ('Long-term customer relationships' asset in Figure 11), which is a complex matter. Also, the cultural obstacle has been detected in the way the firm communicates and learns from the environment at the individual level. Structural change has been identified as the attempt to overcome the cultural impediment in the employee's behavior. Hence, the example confirms the profound effect of the personal values, that coordinate the work at the operational level, on the strategic goal achievement. The development and change of the cultural norms and behavior through the adjustments in the tangible assets is also a complex matter [7]; whereas, the complexity of the resource combination may be seen as a part of the emergent property of the system [72]. However, the resource complexity is not addressed in this study but is a topic for future work.
- Therewith, by using the presented method, it has been also possible to show how the structural design may influence the appropriateness of the different types of learning within the product

development, adaptive and generative. It is argued that the processes and activities represent the depositories of precious skills and experiences that are also very effective in diffusing the 'lessons learned in one part of the organization to another' [7, p. 167]. Hence, removing, adding, or redesigning the processes leads to either the loss or gain of certain skills and experiences. In the presented case example, before the structural change, i.e., in the reactive way of working, each R&D unit was building a unique set of skills during the development of a specific product or a feature. However, it is also important to pay attention to how these unique resources are coordinated. For instance, Figure 10 illustrates that the product development process is coordinated by the product requirements obtained from the customer. The situation illustrates adaptive learning because the process does not question the relevance of the requirements obtained from the customers, i.e., corresponds to the reactive way of serving the market. Since the value of these specific skills to the organization as a whole can be only increased if the organization can effectively capitalize on the bank of expertise, knowledge, and experience [7], this case situation might be viewed as ineffective in capitalizing such value at the organizational strategic level. Hence, the introduction of a more complex organizational structure can be seen as an attempt to address the ineffectiveness. New processes, such as 'Analysis of the external information' or 'Product strategy development' (Figure 11), add value to the existing organizational competencies through the development and coordination of the routines that acquire experience and knowledge on the cross-departmental/functional level. Thus, the broader and more complex coordinating mechanism has been enabled with the introduction of the tangible asset 'Holistic, long-term product strategy' (see Figure 11). This asset directs and controls the product development processes not only at the operational level but also at the strategic, including the strategy development functions inside and outside the organization (e.g., customer or partner, see Figure 11). Therefore, this situation corresponds to the generative learning, which represents the basis for the high-level organizational capability in the constructs of FEM (such as in Figure 8).

8 Future Work and Limitations

It is desirable to continue the research looking deeper into the aspects described in this article. Particularly, there is a need to investigate deeper how to approach modeling for the identification of the emergent system properties, i.e., to understand how the intangible assets are intertwined with the physical elements in the organizational system, as well as how they affect the behavior of the system; and how to visualize the complexity of the resources at each Value Innovation rung through a unique combination of the basic intangible resources (or assets in FEM). The hierarchical approach to the intangibles, as an option, can be used for that purpose. Such visualization may help to uncover the aspects influencing the complexity and difficulty level at each resource transformation rung. For instance, personal values and beliefs, as well as the organization's culture and HR strategies may have a significant impact. The linkages within and between the intangible resource hierarchy and their rungs may help to understand how the uniqueness of the resources emerges at the higher level of their development, i.e., the emergent properties of the organizational system. Therefore, it is also desirable to investigate deeper how FEM may be used in the analysis of the learning feedback loops representing the concept of the triple-loop described by [33], [34], [104]. The examples of the future research topics are: 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 should also focus on employing more of the empirical trials. Such experience can generate more knowledge and raise more questions about how to approach holistic business analysis using EM.

From the practical perspective, the results of this study enhance the understanding of what aspects in the low level of the organizational sub-system influence its strategy implementation. Such an understanding may improve a holistic business analysis; however, the results presented here are limited to one practical application in a particular domain and are based on the knowledge, views, and perceptions of a single senior manager. Also, it has to be pointed out that the study was completed by a relatively inexperienced researcher, and it is desirable to engage more experts. In addition, the modeling work has been performed by a researcher familiar with the FEM toolkit. Hence, the perceived usefulness of the fractal technique might be questioned when it is used by an inexperienced practitioner. Therefore, the dissemination of the tool among practitioners is desirable.

9 Conclusion

The problem addressed in this work is the lack of conceptual navigation to represent and analyze the intangible resources using EM, in particular FEM. The research follows the DSR methodology. The article proposes the meta-modeling technique for how FEM can be used in the modeling and the analysis of the intangible resource level of development within an organization, i.e., the human resources, the organizational competencies, and the organizational capabilities. The real-world organizational settings have been deployed to demonstrate the method's applicability. The result indicates that FEM language is expressive enough to represent the intangible resource hierarchy, for which the modeling patterns have been distinguished. In particular, it has been possible to note the difference between human assets, human resources, organizational competence, and organizational capability. The human asset is denoted by the interconnections between the processes and the tangible human assets that perform the process. The human resource is denoted by the explicit interconnections between the human asset and the intangible tacit knowledge assets possessed by a particular human asset. Hence, by analyzing at which level the tacit knowledge is created and coordinated, from the personal to the organizational, it has been possible to denote the human resource, the competence, and the capability levels in the resource development. This meta-modeling approach has been also proven useful in practice for understanding how intangible resources, such as knowledge, can be affected by structural change, i.e., how the organizational structure may influence the organization's success in the strategic goal achievement. Using this approach, the analyzing type of patterns have been identified during the real case analysis, e.g., the reactive and the proactive way of working within the product development activities. These patterns can be reused in the analyses of similar situations by applying the modeling methods presented in this article.

References

[1] M. Greco, L. Cricelli, and M. Grimaldi, "A strategic management framework of tangible and intangible assets," *European Management Journal*, vol. 31, no. 1, pp. 55–66, 2013. Available: https://doi.org/10.1016/j.emj.2012.10.005

[2] H. Alves, J. J. Ferreira, and C. I. Fernandes, "Customer's operant resources effects on co-creation activities," *Journal of Innovation & Knowledge*, vol. 1, no. 2, pp. 69–80, 2016. Available: https://doi.org/10.1016/j.jik.2016.03.001

[3] S. Madhavaram and S. D. Hunt, "The service-dominant logic and a hierarchy of operant resources: developing masterful operant resources and implications for marketing strategy," *J. of the Acad. Mark. Sci.*, vol. 36, no. 1, pp. 67–82, 2008. Available: https://doi.org/10.1007/s11747-007-0063-z

[4] D. W. De Long and L. Fahey, "Diagnosing cultural barriers to knowledge management," *AMP*, vol. 14, no. 4, pp. 113–127, 2000. Available: https://doi.org/10.5465/ame.2000.3979820

[5] P. Loucopoulos, C. Stratigaki, M. H. Danesh, G. Bravos, D. Anagnostopoulos, and G. Dimitrakopoulos, "Enterprise Capability Modeling: Concepts, Method, and Application," in *2015 International Conference on Enterprise Systems (ES)*, IEEE, 2015, pp. 66–77. Available: https://doi.org/10.1109/ES.2015.14

[6] J. Suriñach and R. Moreno, “Introduction: Intangible Assets and Regional Economic Growth,” *Regional Studies*, vol. 46, no. 10, pp. 1277–1281, 2012. Available: https://doi.org/10.1080/00343404.2012.735087

[7] F. Graetz, A. Smith, M. Rimmer, and A. Lawrence, *Managing Organisational Change 3E*. Melbourne: Wiley, 2010.

[8] R. M. Grant, *Contemporary strategy analysis: text and cases*. Chichester, West Sussex, United Kingdom: Wiley, 2016.

[9] K. A. Melachroinos and N. Spence, “The Impact of Intangible Assets on Regional Productivity Disparities in Great Britain,” *Environ Plan A*, vol. 46, no. 3, pp. 629–648, 2014. Available: https://doi.org/10.1068/a46236

[10] A. Nonnis, A. Bounfour, and K. Kim, “Knowledge spillovers and intangible complementarities: Empirical case of European countries,” *Research Policy*, vol. 52, no. 1, p. 104611, 2023. Available: https://doi.org/10.1016/j.respol.2022.104611

[11] P. Pant, S. Dutta, and S. P. Sarmah, “Intangible supply chain complexity, organizational structure and firm performance,” *IJLM*, vol. 32, no. 4, pp. 1214–1241, 2021. Available: https://doi.org/10.1108/IJLM-06-2020-0239

[12] F. Qing, G. Tan, C. Sun, and P. Chen, “Research on Knowledge Organization of Intangible Cultural Heritage Based on Metadata,” *ITAL*, vol. 41, no. 2, 2022. Available: https://doi.org/10.6017/ital.v41i2.14093

[13] J. Ferreira, A. Coelho, and L. Moutinho, “Dynamic capabilities, creativity and innovation capability and their impact on competitive advantage and firm performance: The moderating role of entrepreneurial orientation,” *Technovation*, vol. 92–93, p. 102061, 2020. Available: https://doi.org/10.1016/j.technovation.2018.11.004

[14] M.-I. Sanchez-Segura, G.-L. Dugarte-Peña, F. Medina-Dominguez, and C. García De Jesús, “System dynamics and agent-based modelling to represent intangible process assets characterization,” *Kybernetes*, vol. 47, no. 2, pp. 289–306, 2018. Available: https://doi.org/10.1108/K-03-2017-0102

[15] A. Fayoumi and P. Loucopoulos, “Bridging the Strategy Execution Gap of Designing Intelligent Talent Acquisition Systems Using Enterprise Modelling and Simulation,” *Enterprise Information Systems*, vol. 17, no. 6, p. 2005149, 2023. Available: https://doi.org/10.1080/17517575.2021.2005149

[16] W. Kucharska, “Wisdom from Experience Paradox: Organizational Learning, Mistakes, Hierarchy and Maturity Issues,” *EJKM*, vol. 19, no. 2, pp. pp105-117, 2021. Available: https://doi.org/10.34190/ejkm.19.2.2370

[17] T. Beliaeva, A. Bounfour, and A. Nonnis, “Modelling intangibles at the regional level in Europe: what lessons from a multidimensional approach?” *Knowledge Management Research & Practice*, vol. 21, no. 3, pp. 637–650, 2021. Available: https://doi.org/10.1080/14778238.2021.1941359

[18] W. Aalst, J. Desel, and A. Oberweis, *Business process management: models, techniques, and empirical studies*. Lecture notes in computer science, vol. 1806, Springer, 2000. Available: https://doi.org/10.1007/3-540-45594-9

[19] Goal modelling. Encyclopedia, Science News & Research Reviews. Available: https://academic-accelerator.com/encyclopedia/goal-modeling

[20] A. Caetano, A. R. Silva, and J. Tribolet, “A role-based enterprise architecture framework,” in *Proceedings of the 2009 ACM symposium on Applied Computing*, Honolulu Hawaii: ACM, 2009, pp. 253–258. Available: https://doi.org/10.1145/1529282.1529337

[21] G. Giustiziero, T. Kretschmer, D. Somaya, and B. Wu, “Hyperspecialization and hyperscaling: A resource-based theory of the digital firm,” *Strategic Management Journal*, vol. 44, no. 6, pp. 1391–1424, 2023. Available: https://doi.org/10.1002/smj.3365

[22] Y. Ren, K.-J. Wu, M. K. Lim, and M.-L. Tseng, “Technology transfer adoption to achieve a circular economy model under resource-based view: A high-tech firm,” *International Journal of Production Economics*, vol. 264, p. 108983, 2023. Available: https://doi.org/10.1016/j.ijpe.2023.108983

[23] B. Demil and X. Lecocq, “Business Model Evolution: In Search of Dynamic Consistency,” *Long Range Planning*, vol. 43, no. 2, Art. no. 2, 2010. Available: https://doi.org/10.1016/j.lrp.2010.02.004

[24] M. Moradi and B. Vallespir, “Knowledge Management and Enterprise Modelling: A Complementary View,” *IFAC Proceedings Volumes*, vol. 40, no. 18, pp. 67–72, 2007. Available: https://doi.org/10.3182/20070927-4-RO-3905.00013

[25] M. Osinski, P. M. Selig, F. Matos, and D. J. Roman, “Methods of evaluation of intangible assets and intellectual capital,” *Journal of Intellectual Capital*, vol. 18, no. 3, pp. 470–485, 2017. Available: https://doi.org/10.1108/JIC-12-2016-0138

[26] V. Allee, “Value network analysis and value conversion of tangible and intangible assets,” *Journal of Intellectual Capital*, vol. 9, no. 1, pp. 5–24, 2008. Available: https://doi.org/10.1108/14691930810845777

[27] S. Bittmann, M. Fellmann, and O. Thomas, “Enterprise Wikis and Enterprise Modelling Environments: An Integrative Framework for Purposefully Using Both,” in *2013 IEEE 15th Conference on Business Informatics*, IEEE, 2013, pp. 374–381. Available: https://doi.org/10.1109/CBI.2013.61

[28] M. Rappl, M. L. Bergmann, and A. Fay, “Formalization of a Product-Process-Resource Model within Aircraft Component Maintenance, Repair, and Overhaul,” in *2023 IEEE 21st International Conference on Industrial Informatics (INDIN)*, IEEE, 2023, pp. 1–7. Available: https://doi.org/10.1109/INDIN51400.2023.10218093

[29] G. Weichhart, C. Stary, and F. Vernadat, “Enterprise modelling for interoperable and knowledge-based enterprises,” *International Journal of Production Research*, vol. 56, no. 8, pp. 2818–2840, 2018. Available: https://doi.org/10.1080/00207543.2017.1406673

[30] G. Stale and I. Majors, “Applying knowledge Management methods and enterprise modelling solution to the IT ecosystem for continuing education in SME’s,” in *4th IEEE International Conference on Digital Ecosystems and Technologies*, IEEE, 2010, pp. 464–469. Available: https://doi.org/10.1109/DEST.2010.5610604

[31] M. Javidan, “Core competence: What does it mean in practice?” *Long Range Planning*, vol. 31, no. 1, Art. no. 1, 1998. Available: https://doi.org/10.1016/S0024-6301(97)00091-5

[32] C. Argyris and D. Schön, *Organisational learning: A theory of action perspective*. Addison Reading, 1978.

[33] P. Tosey, M. Visser, and M. N. Saunders, “The origins and conceptualizations of “triple-loop” learning: A critical review,” *Management Learning*, vol. 43, no. 3, pp. 291–307, 2012. Available: https://doi.org/10.1177/1350507611426239

[34] K. Yuthas, J. F. Dillard, and R. K. Rogers, “Beyond Agency and Structure: Triple-Loop Learning,” *Journal of Business Ethics*, vol. 51, no. 2, pp. 229–243, 2004. Available: https://doi.org/10.1023/B:BUSI.0000033616.14852.82

[35] D. J. Teece, G. Pisano, and A. Shuen, “Dynamic Capabilities and Strategic Management,” *Strategic Management Journal*, vol. 18:7, pp. 509–533, 1997. Available: https://doi.org/10.1002/(SICI)1097-0266(199708)18:7<509::AID-SMJ882>3.0.CO;2-Z

[36] S. G. Winter, “Understanding dynamic capabilities,” *Strategic Management Journal*, vol. 24, no. 10, pp. 991–995, Oct. 2003. Available: https://doi.org/10.1002/smj.318

[37] P. Schoemaker, “How to Link Strategic Vision to Core Capabilities,” *Sloan Management Review*, 34, pp. 67–81, 1992.

[38] E. Danneels, “The Dynamics of Product Innovation and Firm Competences,” *JSTOR*, vol. 27, no. 12, pp. 1095–1121, 2002. Available: https://doi.org/10.1002/smj.275

[39] V. E. Jancenelle, “Tangible−Intangible resource composition and firm success,” *Technovation*, vol. 108, p. 102337, 2021. Available: https://doi.org/10.1016/j.technovation.2021.102337

[40] T.-Y. Shih and C.-C. Yang, “Generating Intangible Resource and International Performance: Insights into Enterprises Organizational Behavior and Capability at Trade Shows,” *Journal of Business Economics and Management*, vol. 20, no. 6, pp. 1022–1044, 2019. Available: https://doi.org/10.3846/jbem.2019.10513

[41] M. Del Baldo and F. Palazzi, “High-Growth Benefit Corporations: Leveraging on Intangibles—Insights from Italy,” *Sustainability*, vol. 15, no. 14, p. 10974, 2023. Available: https://doi.org/10.3390/su151410974

[42] M. Bavdaž, A. Bounfour, J. Martin, A. Nonnis, G. Perani, and T. Redek, “Measuring Investment in Intangible Assets,” in *Advances in Business Statistics, Methods and Data Collection*, 1st ed., Wiley, 2023, pp. 79–103. Available: https://doi.org/10.1002/9781119672333.ch5

[43] B. Thalheim, “The Theory of Conceptual Models, the Theory of Conceptual Modelling and Foundations of Conceptual Modelling,” in *Handbook of Conceptual Modeling*, Springer, 2011, pp. 543–577. Available: https://doi.org/10.1007/978-3-642-15865-0_17

[44] I. Davies, P. Green, M. Rosemann, and S. Gallo, “Conceptual Modelling – What and Why in Current Practice,” in *Conceptual Modeling – ER 2004, Lecture Notes in Computer Science*, Springer, vol. 3288, pp. 30–42, 2004. Available: https://doi.org/10.1007/978-3-540-30464-7_4

[45] M. A. Valentine, “Renegotiating Spheres of Obligation: The Role of Hierarchy in Organizational Learning,” *Administrative Science Quarterly*, vol. 63, no. 3, pp. 570–606, 2018. Available: https://doi.org/10.1177/0001839217718547

[46] J. S. Brown and P. Duguid, “Knowledge and Organization: A Social-Practice Perspective,” *Organization Science*, vol. 12, no. 2, pp. 198–213, 2001. Available: https://doi.org/10.1287/orsc.12.2.198.10116

[47] P. M. Senge, *The Fifth Discipline: The art and practice of the learning organization*. Milson Point, NSW: Random House, 1992.

[48] Wokingham, G. Probst, and B. Buchel, *Organisational learning: the competitive advantage for the future*. Hemel Hempstead: Prentice Hall Europe, 1997.

[49] I. Bider, E. Perjons, and V. Klyukina, “Tool Support for Fractal Enterprise Modeling,” in *Domain-Specific Conceptual Modeling*, Springer, 2022, pp. 205–229. Available: https://doi.org/10.1007/978-3-030-93547-4_10

[50] V. Klyukina, I. Bider, and E. Perjons, “Patterns for Using Fractal Enterprise Modelling in Operational Decision-Making,” in *Enterprise Information Systems, Lecture Notes in Business Information Processing*, Springer, vol. 455, pp. 445–464, 2022. Available: https://doi.org/10.1007/978-3-031-08965-7_23

[51] V. Vaishnavi and W. Kuechler, *Design science research methods and patterns: innovating information and communication technology*. Boca Raton: Auerbach Publications, 2008.

[52] I. Juhani, “A Paradigmatic Analysis of Information Systems As a Design Science,” *Scandinavian Journal of Information Systems*, vol. 19, no. 2, pp. 39–64, 2007.

[53] A. Hevner, “A three cycle view of design science research,” *Scandinavian Journal of Information Systems*, vol. 19, no. 2, pp. 87–92, 2007.

[54] A. van Lamsweerde, *Requirements engineering: from system goals to UML models to software specifications*. Chichester, England ; Hoboken, NJ: John Wiley, 2009.

[55] P. Loucopoulos and W. M. N. W. Kadir, “BROOD: Business Rules-driven Object Oriented Design,” *Journal of Database Management*, vol. 19, no. 1, pp. 41–73, 2008. Available: https://doi.org/10.4018/jdm.2008010103

[56] OMG, Business Process Model and Notatio (BPMN). 2011. Available: https://www.omg.org/spec/BPMN/2.0/PDF

[57] ArchiMate. Available: https://www.archimatetool.com/

[58] J. Krogstie, “Combining Top-down and Bottom-up Modelling for Agile Enterprises,” in *AMINO Workshop – Model-driven Organizations*, 2015.

[59] J. Olhager, M. Rudberg, and J. Wikner, “Long-term capacity management: Linking the perspectives from manufacturing strategy and sales and operations planning,” *International Journal of Production Economics*, vol. 69, no. 2, pp. 215–225, 2001. Available: https://doi.org/10.1016/S0925-5273(99)00098-5

[60] J. Stirna and A. Persson, “Ten Years Plus with EKD: Reflections from Using an Enterprise Modelling Method in Practice,” in *The 12th Workshop on Exploring Modelling Methods for Information Systems Analysis and Design (EMMSAD)*, 2007.

[61] K. Milferstedt *et al.*, “The importance of filamentous cyanobacteria in the development of oxygenic photogranules,” *Scientific Reports*, vol. 7, no. 1, p. 17944, 2017. Available: https://doi.org/10.1038/s41598-017-16614-9

[62] F. Dalpiaz, X. Franch, and J. Horkof, “iStar 2.0 Language Guide,” 2016.

[63] B. Dettori, E. Marrocu, and R. Paci, “Total Factor Productivity, Intangible Assets and Spatial Dependence in the European Regions,” *Regional Studies*, vol. 46, no. 10, pp. 1401–1416, 2012. Available: https://doi.org/10.1080/00343404.2010.529288

[64] B. Dańska-Borsiak and I. Laskowska, “Selected Intangible Factors Of Regional Development: An Analysis Of Spatial Relationships,” *Comparative Economic Research. Central and Eastern Europe*, vol. 17, no. 4, pp. 23–41, 2014. Available: https://doi.org/10.2478/cer-2014-0030

[65] C. Dreger, G. Erber, and H. Wesker, “Impacts of Intangible Assets on Regional Growth and Unemployment,” *SSRN Journal*, 2011. Available: https://doi.org/10.2139/ssrn.2346135

[66] V. Klyukina, I. Bider, and E. Perjons, “Does Fractal Enterprise Model Fit Operational Decision Making?” in *Proceedings of the 23rd International Conference on Enterprise Information Systems*, vol. 2, 2021, pp. 613–624. Available: https://doi.org/10.5220/0010407306130624

[67] V. Klyukina, “Fractal Enterprise Modelling in Strategic Management: Empirical Study in Product Innovation,” in *BIR 2022 Workshops and Doctoral Consortium*, CEUR-WS.org, vol. 3223, pp. 104–115, 2022.

[68] J. Krogstie, *Model-based development and evolution of information systems. A quality approach*. Springer, 2012. Available: https://doi.org/10.1007/978-1-4471-2936-3

[69] M. Smajevic, S. Hacks, and D. Bork, “Using Knowledge Graphs to Detect Enterprise Architecture Smells,” in *The Practice of Enterprise Modeling, Lecture Notes in Business Information Processing*, Springer, vol. 432, 2021, pp. 48–63. Available: https://doi.org/10.1007/978-3-030-91279-6_4

[70] A. Fayoumi, “Toward an Adaptive Enterprise Modelling Platform,” in *The Practice of Enterprise Modeling, Lecture Notes in Business Information Processing*, Springer, vol. 335, 2018, pp. 362–371. Available: https://doi.org/10.1007/978-3-030-02302-7_23

[71] S. Blanc-Serrier, Y. Ducq, and B. Vallespir, “Organisational interoperability characterisation and evaluation using enterprise modelling and graph theory,” *Computers in Industry*, vol. 101, pp. 67–80, 2018. Available: https://doi.org/10.1016/j.compind.2018.04.012

[72] R. Giachetti, *Design of Enterprise Systems: Theory, Architecture, and Methods*. CRC Press, 2016. Available: https://doi.org/10.1201/9781439882894

[73] R. Espejo and A. Gill, “The viable system model as a framework for understanding organizations,” *Phrontis Limited & Syncho Limited*, 1997.

[74] V. Klyukina, “Towards Holistic Enterprise Modelling: Value Creation Concept in Fractal Enterprise Model (FEM),” in *Proceedings of the 24th International Conference on Enterprise Information Systems*, vol. 2, 2022, pp. 535–542. Available: https://doi.org/10.5220/0011075500003179

[75] P. Hoverstadt, *The fractal organization: creating sustainable organizations with the viable system model*. Hoboken, Wiley, 2013.

[76] V. Klyukina, “Detecting Value Capture Processes Using Fractal Enterprise Model (FEM),” in *The Practice of Enterprise Modeling, Lecture Notes in Business Information Processing*, Springer, vol. 432, pp. 80–89, 2021. Available: https://doi.org/10.1007/978-3-030-91279-6_6

[77] D. Bork, R. A. Buchmann, D. Karagiannis, M. Lee, and E.-T. Miron, “An Open Platform for Modeling Method Conceptualization: The OMiLAB Digital Ecosystem,” *Communications of the Association for Information Systems*, vol. 44, pp. 673–679, 2019. Available: https://doi.org/10.17705/1CAIS.04432

[78] K. Peffers, T. Tuunanen, M. A. Rothenberger, and S. Chatterjee, “A Design Science Research Methodology for Information Systems Research,” *Journal of Management Information Systems*, vol. 24, no. 3, Art. no. 3, 2007. Available: https://doi.org/10.2753/MIS0742-1222240302

[79] I. Bider and E. Perjons, “Using Fractal Enterprise Model to Assist Complexity Management,” in *Joint Proceedings of the BIR 2018 Short Papers, Workshops and Doctoral Consortium co-located with 17th International Conference Perspectives in Business Informatics Research (BIR 2018)*, CEUR-WS.org, vol. 2218, pp. 233–238, 2018.

[80] I. Bider and E. Perjons, ‘Defining Transformational Patterns for Business Model Innovation’, in *Perspectives in Business Informatics Research, Lecture Notes in Business Information Processing*, Springer, vol. 330, pp. 81–95, 2018. Available: https://doi.org/10.1007/978-3-319-99951-7_6

[81] H. A. Simon, *The sciences of the artificial.* The MIT Press, 2019.

[82] M. Denscombe, *The good research guide: research methods for small-scale social research projects*. Open University Press, 2021.

[83] W. D. Fernandez, H. Lehmann, and A. Underwood, “Rigor and Relevance in Studies of IS Innovation: A Grounded Theory Methodology Approach,” in *ECIS 2002 Proceedings*, 2002.

[84] R. K. Yin, *Case Study Research Design and Methods*. Thousand Oaks, CA: Sage, 2014.

[85] K. N. Barker, “Data Collection Techniques: Observation,” *American Journal of Hospital Pharmacy*, vol. 37, no. 9, pp. 1235–1245, 1980. Available: https://doi.org/10.1093/ajhp/37.9.1235

[86] B. B. Kawulich, “Participant Observation as a Data Collection Method,” *Forum: qualitative social research*, vol. 6, no. 2, 2005. Available: https://doi.org/10.17169/fqs-6.2.466

[87] Y. L. Doz and H. Thanheiser, “Regaining Competitiveness: A Process of Organisational Renewal,” in *Strategic Thinking, Leadership and the Management of Change*, 1993.

[88] E. Nybakk and J. I. Jenssen, “Innovation Strategy, Working Climate, and Financial Performance in Traditional Manufacturing Firms: An Empirical Analysis,” *Int. J. Innov. Mgt.*, vol. 16, no. 02, p. 1250008, 2012. Available: https://doi.org/10.1142/S1363919611003374

[89] R. Beckhard and W. Pritchard, *Changing the essence: the art of creating and leading fundamental change in organizations*. 1st ed. The Jossey-Bass management series. Jossey-Bass Publishers, 1992.

[90] E. Wenger, *Communities of practice: learning, meaning and identity*. Cambridge University Press, 2002.

[91] A. C. Edmondson, “The Local and Variegated Nature of Learning in Organizations: A Group-Level Perspective,” *Organization Science*, vol. 13, no. 2, pp. 128–146, 2002. Available: https://doi.org/10.1287/orsc.13.2.128.530

[92] T. G. Cummings and C. G. Worley, *Organization development & change*. Stamford, CT: Cengage Learning, 2015.

[93] R. Gulati and H. Singh, “The Architecture of Cooperation: Managing Coordination Costs and Appropriation Concerns in Strategic Alliances,” *Administrative Science Quarterly*, vol. 43, no. 4, pp. 781–814, 1998. Available: https://doi.org/10.2307/2393616

[94] R. W. Cooksey, “‘Learnership’ in complex organisational textures,” *Leadership & Organization Development Journal*, vol. 24, no. 4, pp. 204–214, 2003. Available: https://doi.org/10.1108/01437730310478075

[95] I. Palmer and C. Hardy, *Thinking about management: implications of organizational debates for practice*. Thousand Oaks, CA: Sage Publications, 2000.

[96] A. S. Bollinger and R. D. Smith, “Managing organizational knowledge as a strategic asset,” *Journal of Knowledge Management*, vol. 5, no. 1, pp. 8–18, 2001. Available: https://doi.org/10.1108/13673270110384365

[97] J. F. Christensen, “Innovative Assets And Inter-Asset Linkages – A Resource-Based Approach To Innovation,” *Economics of Innovation and New Technology*, vol. 4, no. 3, pp. 193–210, 1996. Available: https://doi.org/10.1080/10438599600000009

[98] S. R. Gubbi and B. Elango, “Resource Deepening Vs. Resource Extension: Impact on Asset-Seeking Acquisition Performance,” *Manag Int Rev*, vol. 56, no. 3, pp. 353–384, 2016. Available: https://doi.org/10.1007/s11575-016-0282-y

[99] J. Barney, “Firm Resources and Sustained Competitive Advantage,” *Journal of Management*, vol. 17, no. 1, pp. 99–120, 1991. Available: https://doi.org/10.1177/014920639101700108

[100] M. Tushman and P. Anderson, *Managing strategic innovation and change: a collection of readings*. Oxford University Press, 2004.

[101] D. J. Teece, “Business Models, Business Strategy and Innovation,” *Long Range Planning*, vol. 43, no. 2–3, pp. 172–194, 2010. Available: https://doi.org/10.1016/j.lrp.2009.07.003

[102] H. K. S. Lam, A. C. L. Yeung, and T. C. E. Cheng, “The impact of firms’ social media initiatives on operational efficiency and innovativeness,” *Journal of Operations Management*, vol. 47–48, no. 1, pp. 28–43, 2016. Available: https://doi.org/10.1016/j.jom.2016.06.001

[103] P. M. Senge, “Transforming the practice of management,” *Human Resource Development Quarterly*, vol. 4, no. 1, pp. 5–32, 1993. Available: https://doi.org/10.1002/hrdq.3920040103

[104] A. Georges L. Romme and A. Van Witteloostuijn, “Circular organizing and triple loop learning,” *Journal of Organizational Change Management*, vol. 12, no. 5, pp. 439–454, 1999. Available: https://doi.org/10.1108/09534819910289110