A Five-Factor Market Approach for Long-Term Product Development: A Result of Systems Thinking

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***Abstract*— Current product development practices face challenges when adapting to long-term changes in early-stage development. This challenge happens due to missing awareness of the future dynamic conditions that influence future market conditions. This paper introduces five factors to investigate the future dynamic complexities for product development organizations. Findings show interdependencies between the factors, Business model, Politics and regulation, Trends, Funding and Insurance, and Technology. Each factor consists of an individual system, which can be influenced by each other over time. Further investigation of the interdependencies linking five factors set out to reveal the new and unexplored potential for product development organizations. The paper introduces a systemic approach to facing future challenges of managing long-term product development management.**

Keywords- Systems of systems; Future market.

I. INTRODUCTION

Today, we face the challenge of missing the objectives of the Paris agreement if we continue to produce and develop technologies as we have been doing so far [1] [2]. When managing their project portfolios nowadays, companies have already faced the challenge of predicting short-market conditions as the market is rapidly changing.

However, with the increasing complexity of the world and increasing numbers of near-tipping-point incidents over the last year, the war in Europe, the rising cost of goods, etc., is the green transition, something we all need to participate in. Changes will not emerge by themselves and arise in a magical moment but need development through innovation and research.

For decades, scholars and researchers have claimed that modern product development stresses increased demand for new incremental solutions and is more complex than ever. Could it be that no matter when we develop new technologies, we anticipate the current situation full of unrecognized possibilities and risks and, therefore, see it as the challenges of the time? Therefore, by acknowledging the complexity of the socio-technical, environmental complex reality, we need a dynamic framework for dealing with the dynamics in the complexity or reality to distinguish between complex structures and complicated mechanisms.

Systems thinking is known in multiple works of literature for being able to grasp systems complexity, visualize interdependencies, create an understanding of boundaries, and many more valuable things. Therefore, this makes systems thinking suitable for addressing systems complexity, as we do in this article.

The future market will remain dynamic, and nothing will appear in 10 years as it does today. Moreover, as we acknowledge that market conditions are rapidly changing, we need a framework to identify future uncertainties to help guide organizational development.

The research goal of this paper is to explore the holistic landscape, from an enterprise perspective, for interrelated systems of systems that together shape the conditions for the future development of products and systems. This sum of information from the five factors introduced in this paper, can support portfolio managers in design- and decision-making processes to allocate resources best towards the organizations long-term strategy.

The structure of the paper consists of six sections, where Section I continues to introduce a background overview of and establishes the challenges the paper addresses. Section II presents the methods used in producing the results. Section III introduces the five factors of the market. Section IV addresses some of the direct dynamics in the system. Section V places the five factors into the system of product development introduced in Section I. Section VI concludes and addresses further research.

A. Background

Product development of physical products is becoming more complex as requirements for the green transition are adopted. The green transition influences all product life cycle stages, including the whole value chain [3].

While many companies have adopted some form of an agile workflow in areas of organizations, the portfolio management processes often follow a waterfall–stage gate approach for governing the whole enterprise [4]. This approach has some shortcomings in the later stages of development, where the data collected as part of testing is not returned into the process to feed the early innovation activities (see Figure 1).

Figure 1 illustrates the current portfolio practice in a typical stage gate approach. The flow of the main activities follows from the left top to the bottom right side. At the top, project sponsors provide input on requirements, evaluate the project, and approve the project to continue to the following

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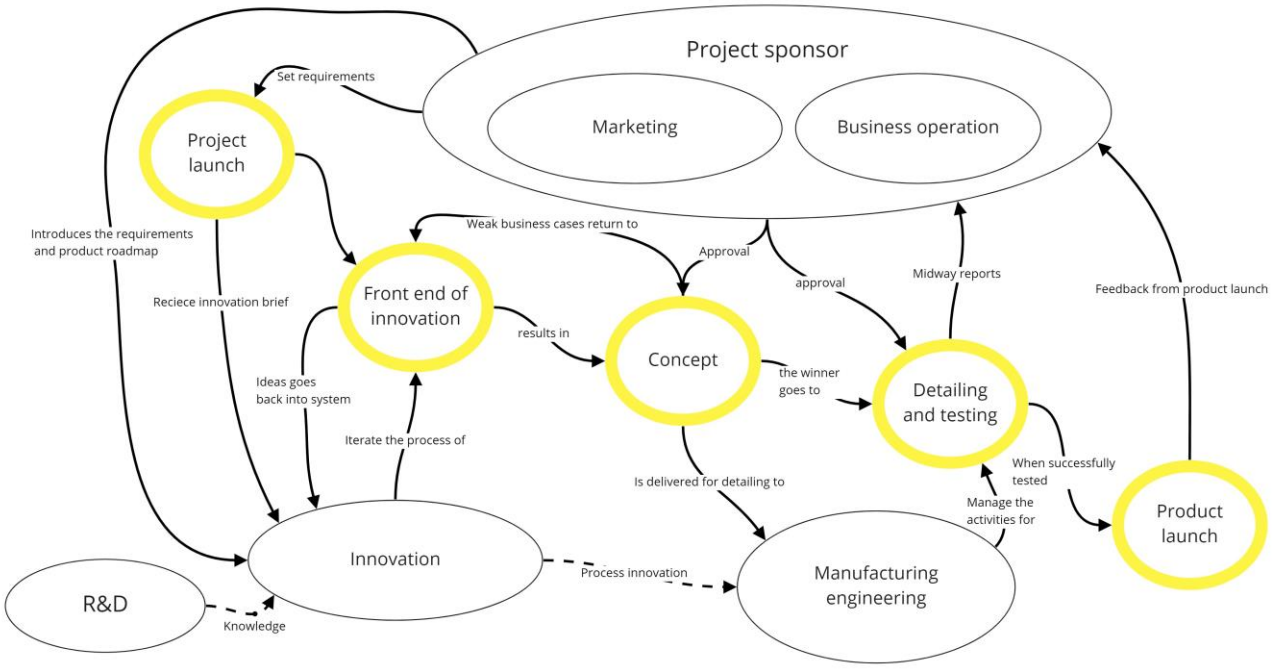

Figure 1. Innovation system of systems.

stages of development. Innovation consists of activities involving inputs from research and development and detailed information on innovation projects and requirements. The output for the process can be in concept ideas or process innovation to improve areas like manufacturing. Manufacturing is responsible for evaluating the concept requirements and manufacturing processes align and make it possible to deliver products that fulfill requirements in cost and quality.

Existing product development practices get the specifications and requirements from various sources (for example, customer interviews, product testing, and sales numbers) [5]. The current way may be holistic but ignores the dynamic perspective of potential future requirements.

Other researchers have addressed uncertainty in project portfolio management and product development of radical innovation [6] [7]. Despite recognizing certain interdependencies, this area has not yet been properly investigated, particularly when it comes to long-term uncertainties in dynamic systems. The traditional product development and innovation methodologies treat each system as singular units, such as law and regulation or technology, and so forth. Thereby overlooking how these seemingly independent systems influence one another by, for example, how technology helps shape and form new laws and regulations by setting collecting data for science-based targets and, consequently, miss addressing the circumstances that enable this dynamic. By ignoring the whole picture, we believe that opportunities and potential are overlooked for systems innovations that truly can impact society and the environment.

B. Challenge

The challenge in the existing systems is the missing consideration of long-term conditions related to each aspect of the system. Various uncertainties must be managed throughout development as potential risks are involved in new product development.

Traditional product development practices tend to look at various inputs to the product development process, taking “influencing factors” as a static parameter in the design process. However, the different factors of uncertainty in product development practices are not static and independent. The individual requirements are, over time, dynamic and connected through mechanisms and processes.

The existing approach for evaluating the influencing factors in product development and portfolio management is segmented and shared between operational units in the organization. The challenge, in this case, as time is a factor, is that implications made in one area of the system will not immediately result in changed behavior in all other affected system elements.

The finite purpose of an organization is to provide products or services to bring value to a market in exchange for money. As the market will be dynamic over time, we see the market as constructed from different influencing factors. Therefore, we will spend the rest of this paper constructing a systems framework to consider the influencing factors that shape the future context for the enterprise and introduce those into the earlier described product development practice. We do this to raises awareness of the interdependencies within the context where organizations develop and deliver products and services. Exploration of uncertainties is essential for designers and managers within product development. Hence, they can focus their innovation

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and possibilities on managing development and resources by understanding each element and its dynamics within their working systems and how these address the circumstances and requirements that affect their projects.

II. METHOD

The data for the system identification was discovered and structured using Checkland's Soft system model [5] [6]. The model introduces a 7-step process where steps 1-4 consist of identifying the existing system and developing a conceptual model of the system in an iterative process. Step 5 uses the conceptual model and learning to raise discussion of challenges in the existing system, which are desirable and feasible. Step 6 consists of developing a suggested to-be version acceptable for all the including world views. Step 7 is to implement the suggested changes into the analyzed system. This final step is out of the scope of this article.

During identifying the different subsystem agents, relations, interfaces, and boundaries, we used the acronym CATWOE to identify the reactive forces and their roots [10]. CATWOE stands for, Customers – identifies who gains or losses value in the process, Actors – identifies who implements the active element, Transformation – What the functions in the system transform, World view – Justification of the system's existence, Owner – Who can establish changes to the system, and Environment – the external condition and constraints.

Finally, a systemigram is a method to introduce the system story of how future strategic impact might benefit companies in their product development [11].

III. INTRODUCTION TO THE SYSTEM

We see the high-level system of systems consisting of five subsystems each as a market influencing factors. Each contributes to shaping the market conditions where the organization operates. Figure 2 shows the five subsystems named: Business model, Technology, Political and regulatory, Trends, and Funding and insurance. The dynamics in the system of systems are complex due to the high number of agents involved in the activities related to each subsystem. Therefore, each following introduction of the subsystems happens in isolation. It is worth noting that, in Figure 2, no human actors are included, but all mentioned elements only exist due to the development and influence of groups and individuals.

A. Business model

The business model is at the core of the system activity, and it is expected of the organization to know its capabilities, placement in the market, and product assortment [12]. The purpose of placing the business model as the core activity is that the company fully controls this element and can adjust accordingly to changes in other systems. Furthermore, a resilient business model can adapt to changes in the remainder of the system.

B. Technological field

The technological fields include existing internal technologies. Technology covers projects in all stages of development, from the conceptual ideas to the preparation for product launch as well as experimental technologies under research and development, existing patents, competing technologies, and planned concepts that already exist in the technological pipeline or road maps.

External technologies are also included and can consist of existing competitive technologies and technologies under development in other companies.

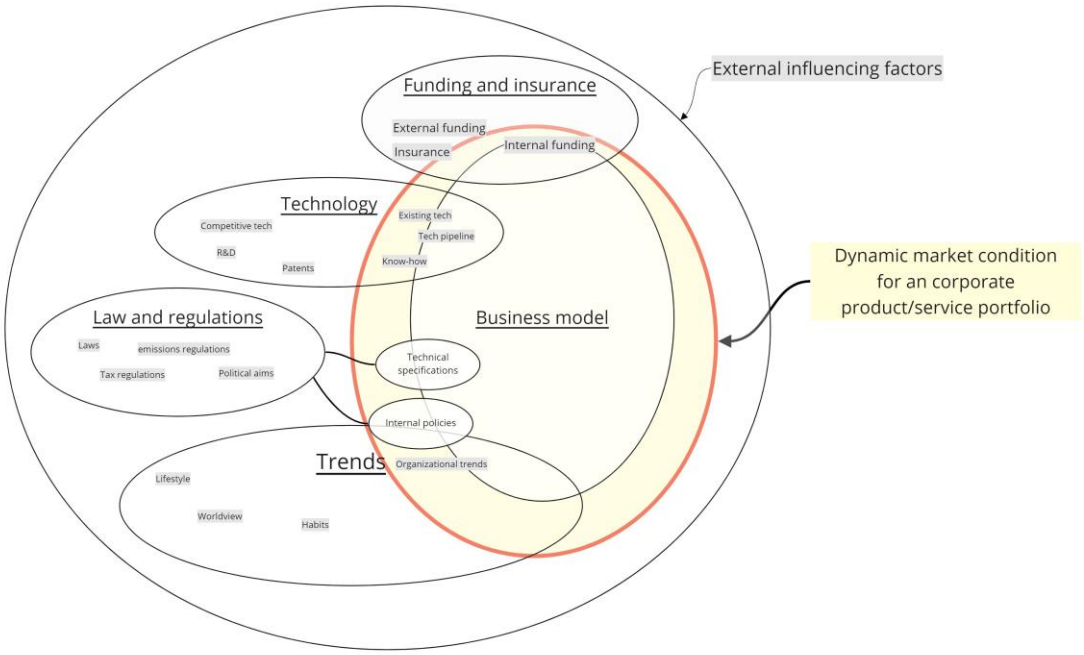

Figure 2. Market influencing systems of systems.

C. The political and regulatory system

The political and regulatory system consists of sections and units working with and developing standards, laws, and regulations. The purpose of this system is to convert political decisions into tools when implemented, either reinforcing a specific systemic behavior or diminishing a systemic behavior. For example, the political decision in the EU parliament to ban throwaway plastic has led to an expansion in the market of single-use cutlery made of wood and bamboo [13].

D. Trends

Specific trends release opportunities for technology development. Therefore, trends are a vital part, of the dynamics, of shaping the existing and future markets. We identify elements in the Trend systems, including lifestyle trends, for example, equality, work-life balance, and Eco-friendly. Other trends including working trends. An example where we have seen movement, especially during the Corona virus pandemic, was when the work environment accepted remote workdays. Such changes open new opportunities for technologies to emerge. Furthermore, we also see organizational trends, which are trends within the management of organizations. For example, new work methods influence the working environment and work behavior.

E. Finance and insurance

Innovation of technologies is highly dependent on the sources of finance supporting development and research. Funding sources can come from internal sources in the organization's budget or external funding by various public and private funds or governmental support.

Some studies indicate high support from governmental funds to support technological development to push society in the desired direction [14]. This is placing financial risk in institutions and constellations where profit is not the overarching purpose. As a result, funding is addressing research activities and specific technological flagship projects that might create a leap in technological development.

Inventing and developing new technologies involves high risks as many uncertainties are related to new and untested technologies. Therefore, insurance of the development activities during the process is essential. Furthermore, insurance of the testing facilities and human interaction is essential and impacts the decisions of what technologies are tested and at what speed technologies can be carried forward.

F. Outside of the system

Outside of the drawn system of systems, we have the macro environment. The model does not include the macro environment because of its reduced effect on the direct subsystems identified earlier. Elements such as resources and materials would be relevant to discuss but are left out of the system mapping since resources and materials are subcomponents for multiple subsystems described earlier. Materials are expected to be a limited resource based on laws and regulations. Also, the tendencies of what the products will consist of are highly dependent on the technology and requirements of the product. Requirements towards material and resources need to follow the regulations of, for example, production, consumption, and recyclability, to name a few. Finally, when discussing materials and resources, companies conduct a cost-benefit analysis of optimizing the specific products for the conditions they will meet in their life cycle. This optimization also relates to insurance as the selection of materials relates to the requirements of robustness needed for the specific technology or product. These different factors are analyzed together with the company's business model.

Other researchers might argue that the market condition is a vital factor for the future approach. We have decided not to include market dynamics because the interdependencies between multiple factors will cover market behavior. For example, political implications can assign regulations in the form of taxation or subsidies that can adjust sales mechanisms and regulate the market of products and services. Such regulations can be combined with production mechanisms used to produce goods or services.

From an enterprise perspective, the business model influences the shaping of market trends. Does the company decide for a fixed production output, or is production possible to adjust? What are the customer relations, and how do the additional factors impact the supply chain?

Trends consists of direction and dynamic patterns within each systems of finance, politics, technology, and human behavior. Trends will, therefore, influence the possibilities and behavior of the market. The result is when reviewing the factors as a function of time, the five factors are all involved as shaping forces for the future market where each factor contributes, individually and as part of a whole, to the behavior of the future market and its dynamics.

IV. THE DYNAMIC IN THE SYSTEM AND HOW THE SYSTEMS REACTS TO CHANGES

Undoubtedly, when looking at the isolated system's elements, it is, in the short term, easy to say that each system is quite static. However, when investigating the influencing factors on the market over an extended period, it becomes apparent that shaping forces influence each other.

Technology development happens according to the company's business model and strategy. Technology development is largely related to the available financial resources, is influenced by the political landscape, and gets constrained by regulations and restrictions in the technological area. The technology takes its form from existing trends in the technology environment, developed through further specifications and requirements, both technical and non-technical. The existing reality also shows how new emerging technologies help shape the political landscape, which becomes evident if we consider what has happened within cyber security, education, and healthcare over the last century. Furthermore, when planned and distributed in certain ways, technologies can support the creation of new trends within society, considering what Apple has done. New technologies such as artificial intelligence also help the Funding and insurance market take risk assessments, decide where to invest, and provide investments and security. Finally, technology is also the

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source for establishing new business models within organizations and companies.

Politics and regulation are one source of new emerging technologies. Funding in development and limitations in legal targets for emission force companies to develop new business models. The political agenda and regulations can also set forward new market trends or trends in public.

The company can also develop a new **business model** that inspires innovative technological development. A part of the business model could also be to investigate how to collect the right among the right source of funding to execute experimental development. Another business model interaction can focus on where politics and regulation might be obsolete within a particular technological field. The value behind such activity could aim at being the first mover and the first to exploit a new market condition. Being the first to get a license to produce or reuse a specific resource could lead to profit and gain the most significant market shares.

Funding and insurance is a vital shaping force in the future market. Particular funding opens up new opportunities for companies to test concepts and ideas, lowering the individual risk of the company going bankrupt or out of business. Companies must still consider insurance as a vital part of new product development. If the company develops a "new to the world technology," it is vital for the people involved, the environment, and the company itself to have security in place. The company's guidelines might support the development of a safe environment until it can be approved as a potential as a future technology.

Trend will also shape future market conditions based on public trends, but trends within technology path dependencies might be challenging to break. If public trans goes into grass root movements, there is a possibility for a new emerging company providing new unseen technical solutions to the marketplace. However, it could also impact the political and regulatory system, especially since grassroots movements tend to collect inspiring people with much energy to push the system into creating their agenda. Due to the private trends, companies must adapt their business models to meet social trends and public awareness. Furthermore, in funding and insurance, there will probably be certain trends within specific areas, for example, green investments portfolios in pension funds, but these trends also shape the public perception of the company's reputation

V. THE SUGGESTED NEW SYSTEM

Figure 3 shows a systemigram of how the new optimized system brings knowledge of the new market condition into the development complexity. We find it helpful to place the five-factor system at the front end of innovation, where market tendencies are researched and explored. The system of a new future market condition should feed the innovation process and inspire new ideas based on potential opportunities in future markets. In addition, the system analysis can feed the top management with information from scenario creation, with uncertainties and potential risks to consider in planning the company's future. Based on the explorative knowledge, the top management gets a better source of information on to base their prediction and decisions. Even though this process does not eliminate the uncertainty, it visualizes and brings forward the uncertainties of the future, and by visualizing future challenges, it allows the company to react and make decisions on how to deal with the uncertainties. Top management can decide to investigate uncertainties and quantify them as risks or opportunities. This investigation will undoubtedly spark inspiration toward innovation projects and new areas to

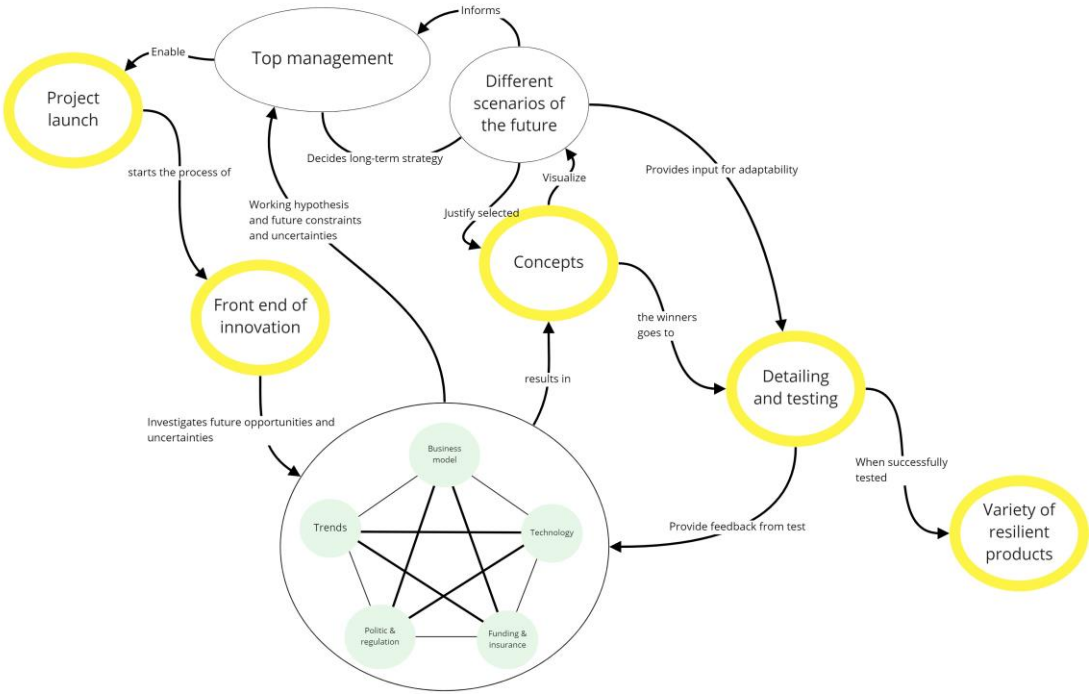

Figure 3. System suggestion for improved market exploration

investigate in the future. As in the old system, top management will evaluate conceptual ideas, but now there is an integrated feedback loop that feeds the latest market-testing and prototype-testing market conditions into the innovation process. The innovation process will catch any change or realization in the testing phase and work as input and constraints in the next iteration. Finally, uncertainties and risks identified in the future scenarios can be included in the product development process to be strengthened and prepared in the pipeline for the next module; this leads to more resilient/adaptable/flexible solutions or technologies to meet future conditions.

VI. CONCLUSION

The research goal set in this paper is to examine the holistic landscape of market-related systems that shape future conditions of products and systems and how information can feed portfolio design- and decision-making.

Through a systems perspective of the organization interfaces with market conditions, and acknowledgment of the future market as dynamic, this paper identifies five factors: Business model, Technology, Political and regulatory, Trends, and Funding and insurance. The paper discusses how these factors are systems of systems and are interrelated and, through various relations, shape the conditions around future solutions. These relations are highly context depended, and every change to a system will influence the possibilities within the system.

Therefore, we suggest using the factors as interrelated systems to analyze future market conditions. We found the system valuable in the front end of innovation within the innovation portfolio exploration and development process. Here, it informs the organization's innovation team and top management with helpful identification of future scenarios and addresses interrelations that might hold business potential that demands further investigation and innovation resources.

Further studies from this field will be industry-related case studies to map the interrelation and identify the relations and actors that shape the dynamics. Furthermore, an analysis of how the interdependencies influence portfolio managers' decision-making. Finally, we will address what to consider what to consider when reviewing the system and analyzing future conditions when establishing and aligning requirements to address and solve societal- and environmental challenges?

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