A Novel Value Driven Co-creation Framework

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Abstract. The Environmental awareness is growing throughout the society and the pressure on manufacturing companies, and their extended value chain, to operate in a more sustainable way. Designing products that can be controlled throughout their value chain and life cycle is one option to secure reuse of the material stream. We hypothesize that increased collaboration and common understanding among industrial stakeholders will promote improved products with regards to sustainability criteria. To test our hypothesizes a model for cross-industry and cross industry and academia collaboration is outlined. This model emphasizes three distinct levels of collaboration, team, company and cluster, and the life cycle stages of a product. Understanding these levels and stages are important not only for assuring correct and rational behavior among actors but also for facilitating a long-term sustainable business model development. This article presents the theories and arguments behind the model and initial results from an aluminum product case. Further verification and calibration of the model will be done by adding case studies as input to the collaboration model.

Keywords: Innovation model, co-creation, aluminium product case study

1 Introduction

Increasing pressure to develop products of higher quality, with added functionality, at a lower cost, and in shorter time frames unquestionably brings about some dichotomies. The examples of high quality vs. low cost, less resources and time vs. higher performance, and increased robustness vs. lower weight all illustrate well known contradictions which become more and more important to optimize. Only companies that can manage such conflicting objectives and in an adaptive manner consistently and timely bring new and innovative products to market will be regarded as long-term partners. In this regard, Utterback [1] claimed that the main challenge is to develop the ability to innovate products, processes, and the organization, seeing them dependent of each other as a whole. To this overall picture, companies must comply to requirements and expectations regarding sustainability criteria as well as increase their understanding and ability to utilize enabling technologies for improving product lifecycle performance.

Product development capability [2], the ability to use and integrate existing organizational and inter-organizational competences, is seen as fundamental to introducing a successful new product. It is argued that success is especially challenged by technology changes and global competition, meaning that product development capability must contain features beyond competence utilization. For instance, Barney [3] emphasized that such capability must be valuable, rare, and imperfectly imitable. Others start from the firm level [4] and see resource utilization as a driving force behind successful product development and competitive advantage. A third stream of literature, with contributors like Nelson and Winter [5], concluded that technological and organizational progress is driven by mechanisms of variation, selection, and retention. Hence, this evolutionary perspective focuses heavily on continuous innovation and mastering of change.

The coming decade is expected to become a crucial period for industrial companies as they more frequently have to respond to global challenges. Environmental awareness is growing throughout the society and the pressure on manufacturing companies to operate in a more sustainable way is increasing. Having control of, and insight into, the entire value chain is becoming a significant part of running a business [6]. However, for many manufacturing companies, that are not distributing their products themselves, knowledge of the complete life cycle of the products is limited. Furthermore, insights into users and end of life stages are particularly restricted. Understanding these stages are important not only for assuring correct behavior but also for facilitating a long-term sustainable business development. On the other side, the amount of available technologies for enabling information tracking throughout the product life cycle is increasing.

Many manufacturing companies do not have control over the distribution chain, and find it difficult to obtain complete information on use and reuse [7]. In many value chains, information exchange is very limited due to lack of interest of sharing knowledge or understanding of what information that is important. The point of departure for industrial design is the end user, on a general level or through deep insights. Insights can be achieved through interviews, observations, experiences or co-design where design for sustainable behaviour aims at supporting greener choices by buyers and users of products.

This paper seeks to initiate a framework for cross-collaboration co-creation strategies towards improved product development processes for a more circular economy.

2 Theory

Innovation today is about bringing together different actors at different levels, ranging from the individual, to the group, organization and inter-organizational levels. The concept of organizational learning is therefore dependent on those groups and teams that are able to learn; if they cannot, the organization cannot learn [8]. This view is supported by Senge [9], who stated, "*team learning is vital because teams, not individuals, are the fundamental learning units in modern organizations.*" Groups are social systems in which sharing, learning, and organizational behavior take place, and they can play a central role in both supporting individual learning and opening new opportunities for interventions. Individual, group and departmental learning are thoroughly discussed in the previous chapters, so the main body of this chapter is concerned with the organizational and the inter-organizational level.

In a complex world system are developed to reduce complexity, and trust may serve as a building block in creating these systems. Luhmann [10] regarded trust as reduction of complexity; he saw trust as a function for establishing and maintaining a complex world. He also argued for trust as an input condition to abstract systems, stating that "*without trust it cannot stimulate supportive activities in situations of uncertainty or risk.*" Giddens [11] defined trust as "*confidence in the reliability of a person or system, regarding a given set of outcomes or events, where that confidence expresses a faith in the probity or love of another, or in the correctness of abstract principles and technical knowledge.*" This means he believed that the result of actions is not random, but is directly linked to the characteristics of the system. As discussed above, the automotive industry has clear characteristics described in the transaction cost economic. By showing trust Giddens [11] argued for a mild form of hostage taking or being called upon. The trusted party will then feel an obligation to act in a certain way, and the actions will be revised during the time of the relationship. In such relations based on trust lies an idea that humans create risk and that this risk cannot be eliminated, only reduced. This is done in a rational and conscious way when the risk can be calculated.

Bowersox et al. [12] defined supply chains as value-adding relations of partially discrete yet interdependent units that cooperatively transform raw materials into finished products through sequential, parallel, and/or network structures. The supply chain management (SCM) literature analyses how firms are affected by their participation in global production networks [13], and it views supply chains as networks of organisations that are involved in different ways to produce value in the form of products and services in the hands of the ultimate consumer [14].

The key technologies developed in the early and mid-20th century were developed primarily by large diversified enterprises. This diversification, along with vertical integration, provided these firms with a competitive advantage over smaller competitors. Realizing the increased knowledge mobility and availability of venture capital to capitalize on knowledge, Chesbrough and Vanhaverbeke concluded that the traditional model had reached its limits [15], and suggested open innovation means a break with the traditional paradigm.

From this Chesbrough and Vanhaverbeke [15] derived the following definition of open innovation: "*Open innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation.*" The increased global flow of goods, services, knowledge and capital implies that firms increasingly obtain ideas and knowledge from distributed knowledge networks and open innovation [16] in addition to their internal knowledge base. This transition from stable conditions, often in local and national markets, to global competition and more tailor made products has also increased the interest in innovation and organizational learning [17]. Tidd et al. [18] asserted that innovation networks have become popular as a means of innovation across organizations. Such networks may be viewed as a new hybrid form of organization that has the potential to replace both firms and markets and create a kind of a *"virtual corporation"*. The model of open innovation by Chesbrough [16] is based on the same idea: to have an open flow of ideas and technology between the firm and its environment. He focused on the notion that good ideas are worthless without capital and a superior business model, saying that firms can and should use both external and internal ideas to create value and internal and external paths to market [15]. This concept draws on for instance the theories of absorptive capacity and spillovers of industrial R&D.

Network ties often reflect formal collaboration, but the knowledge flow, which is the main focus, may be separated into formal and informal ties. The former reflects planned channels for knowledge exchange, whereas the informal ties are viewed as more interesting and valuable due to unforeseen knowledge opportunities [15]. In this perspective the open innovation theory turns into more of a networking perspective, where the competitive advantage can be found in the community of companies rather than in the individual company. On the other hand Lorenz and Valeyre [19] asserted that innovation activities still critically depend on factors internal to the firm, in particular on the job training related to solving technical and production related problems. Another perspective of network innovation models is co-opetition, where collaboration and competition are not mutually exclusive, but can actually coexist and create benefits from joint dynamics among competitors [20]. Evans et al. discuss the advances of sustainable business models, which take into account the extended responsibility companies has for their products and services in value chain and life cycle perspective [21].

3 Method

This study is part of the Norwegian Research Council funded project VALUE, reporting upon 6 in-depth interviews done in one of the application cases. The interviews were recorded and transcribed, and the informants read and approved the transcriptions. This formed the backbone of the case study.

The innovation model, hypothesized to support rapid innovation in the context of developing more complex products with increasing number of interfaces both physically and virtual, is illustrated in Figure 1. There are identified three important, and connected, intra- and inter-organizational levels where learning takes place [22]. The first one is at the team level where a group of individuals are dedicated towards closing knowledge gaps related to product features. The next level emphasizes how knowledge at group level relates to the whole organization. This can be horizontally and vertically integrated knowledge, where the particular product innovation is put into a business context and where knowledge accumulates through tacit and explicit channels. The

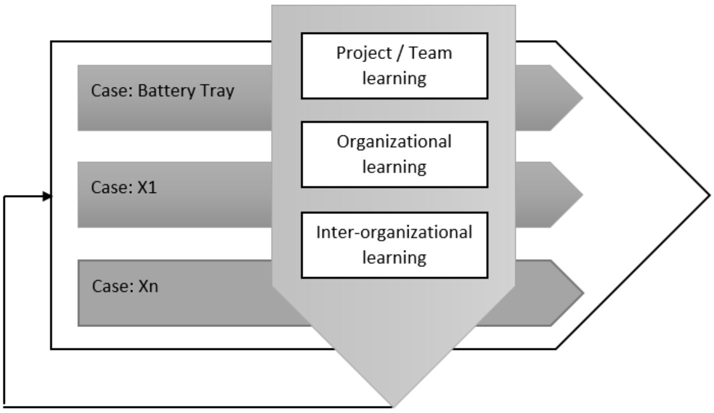

Figure 1. Innovation model.

third level involves inter-organizational learning, and how the network of the firm can be involved to speed up open innovation processes. We will in the following project this model through a real innovation case, and discuss how feedback-loops from the different learning levels can improve the next innovation process according to product lifecycle performance.

4 Results of application case

The case company develops and manufactures critical light-weight safety parts for the automotive industry and has been doing that for more than 50 years. More than 10 million components are supplied to demanding customers annually. However, the electrification trend in the transport sector spurs the need for increasing light-weight solutions to compensate for added total vehicle weight due to batteries. They see that the automotive industry is changing. As a result of the United Nations goal of stopping global warming to a maximum of 2°C increase, heavy regulations have been, and will continue to be implemented to reduce emissions in the transportation industry. This has led to a dramatic and rapid change in the automotive industry towards low and zero emission vehicles.

The electrification of passenger vehicles is arguably the biggest shift in the automotive industry since Henry Ford introduced the assembly line in the early 20th century. The push from the governments are coupled with a few pioneering manufacturers which has demonstrated that the technology is ready to be used and it is possible to produce desirable vehicles which is in demand from customers. Over the past years, especially over the last year, there has been a continuous spate of announcements from car-manufacturers declaring their intensions and plans to electrify their product portfolio. Some have even pledged to only produce electric vehicles, whether they are pure electric or electrified, within the next decade. The change to electric drivetrains comprises new vehicle architecture as traditional requirements for engine, gearbox, driveshafts and fuel tanks are redundant in electric vehicles. These would be replaced by smaller, more compact electric motors coupled with a large battery. As these types of vehicles are weight-critical, the current and future market pull creates new opportunities for suppliers of light-weight materials such as aluminium to be put to use in new areas and products. In this connection, one of the product categories with the larger potential is aluminium battery trays. For the case company battery trays are seen as an interesting and complementary product to the existing product portfolio, where deep knowledge about utilizing and forming aluminium may be a steppingstone towards further growth. However, the case company realises that material and process knowledge derived from the existing markets and product portfolios are not sufficient to take on the assumed complexity of making battery trays. Some of the identified requirements affecting the battery tray are given below:

- The primary task of the battery housing is to protect and enclose the energy required to propel the car.
- The battery cells are temperature sensitive, meaning the efficiency of the battery cells are dependent on operating in a temperature range. If the temperature is too

high, the capacity will decrease along aging of the battery. If the temperature is too low, the internal resistance in the cells increase and performance decrease.

- Protection from moisture, rain, dust and particles is important for the operation and lifetime for the batteries. Therefore, all battery housings are enclosed in one way or another using sealants, high internal air pressure or membranes.
- Safety requirements: As most battery packs are substantial in size and weight, they have significant effects on the crash structure of the car. There are also official requirements for transporting lithium-ion batteries.
- It is desirable to have a lightweight battery housing, as extra weight decreases the efficiency of the car and shortens the driving range.
- The battery housing is not to be a source of vibration, which will affect the safety of the batteries and the comfort of the passengers.
- The battery housing is a highly customized component since it has to incorporate and satisfy designs that comply with the defined size and shape of space in the vehicle, as well as the mounting points to the vehicle, and it must incorporate all the internal components to fit inside the housing.

At the project team level the new product concept, battery tray, was seen as innovative and interesting, although the potential manufacturing processes to be selected for realizing the product were known from before. The potential risks and rewards were more related to the system complexity, where number of sub-components must be assembled in a cost-effective way. Historically the company was used to do welding, a process now done in other parts of the global production network. The team was also discussing the possibility of just developing a product to be produced elsewhere due to assumed high value chain costs of transporting systems to the customer from remote production sites, and the proposed process of do a lot of welding for final assembly. An interesting finding was that this realization of just being part of the initial development phase, spur some ideation among the local team. A novel tooling approach for extruding aluminium profiles was developed to make innovative profile designs, aiming at reducing volume to be transported (50%), reduce welding (50-60%), and increase the panel width (250%). This is one of many initiatives taken at team level, impacting the maturity of a future product concept.

At the level of organizational learning the company has a long history of producing high volume components to demanding customers, controlling the aluminium value chain from casting, extrusion, forming and to final assembly. The combination of long history, value chain control, and a stable workforce at local and regional level over time, lays a good foundation for identifying, transferring, and utilizing knowledge. However, some dynamics in ownership since mid-1990s have influenced this stock of knowledge, especially in terms of customer proximity and how the is organized towards customer satisfaction. Currently, the company is part of large multinational company with a strong foothold in global value chains – such also for the automotive segment. This new way of organizing the local manufacturer gives better access, and a stronger tie, to key customers, but also a potential longer way for information and knowledge to travel from the source to those who are in charge of developing new solutions. However, the accumulated knowledge in terms of an innovative battery tray was presented at the Shanghai Motor Show in 2017.

At the inter-organizational learning added complexity in the product interfaces required a more open innovation process, including a network of academia and industrial partners to create feasible solutions. From a business perspective the case company early identified sets of risk related to be in the value chain of supplying battery trays. First, immature industry standards and fast developing technology are key factors to be carefully evaluated before going into a new product/system segment. Second, technology risk was noted as high due to consequences of not being able to safely protect the batteries under all possible conditions. Third; competence capability is seen as crucial to develop a sustainable solution for an emerging and demanding market. Actions taken to reduce risk were comprehensive. But, being in the business of development and manufacturing of critical aluminium safety parts for decades, one of the most trusted customers was accompanied to form a joint development project. Here risks and opportunities were identified and broken down to small tasks, where also external potential knowledge actors were mapped according to capability and capacity. Examples of sub-tasks are; selection of semi-finished goods, welding techniques, calibration for dimensional accuracy, crash impact, weight optimization etc. Academic partners were selected as contributors to these sub-tasks, but the co-creation intensity and level differentiates depending on actor strength within the field of expertise. On the business side, a broad network of strategic partners was selected to develop a modular and scalable solution for light-weight e-mobility. This solution was ready for launch in 2019.

5 Conclusion

This paper seeks to illustrate the complexity of bringing new innovations to the market, where all levels of the organization, and it's extended network, have to be mobilized in order to close the knowledge gaps. Innovation theory has in recent years developed towards emphasizing cross-boundary and inter-organizational innovation, seeing the value of bringing a broad array of views into consideration when the landscape of developing new products and services become more complex. However, this paper supports the importance of being open, but without forgetting the core of the company. The latter is exemplified by the innovation capability of local engineering teams, combining extrusion and forming skills to prototype entire new solutions. At the organizational level, stating time dependent objectives for closing critical knowledge gaps turned important for urging the organization. Involving academic and strategic business partners is also viewed as important when newness is defined along all the dimensions: market, process and product. We propose an innovation model that integrates this local team innovation capability with the organizational learning and inter-organizational dimensions. Playing out these three capabilities simultaneously when heading for step-change innovation in in-mature markets is valuable when doing it carefully and with awareness. This is the key finding from this paper. We will continuously develop this innovation model based on additional cases.

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