Bridging the Gap: From Open Innovation to an Open Product-Life-Cycle by Using Open-X Methodologies

Matthias R. Gürtler, Andreas Kain and Udo Lindemann

Abstract Open-X methodologies describe the application of Open Innovation to different stages of the Product-Life-Cycle (PLC). Open Innovation deals with involving external players in a company's innovation process. Those can provide ideas from any stage of the PLC, such as lead users in the development stage or product-users in the utilization stage. These ideas themselves can initiate innovations in any PLC stage. However, this typically affects the development of new products. This means that ideas collected are incorporated into early PLC stages only. There is significant potential in using ideas not only for early stages but also for later stages, which means for existing products. Open-Utilization, as one form of the Open-X methodologies, can create innovations in the form of upgrades or new services for a product. Because respective PLC stages are not equally suitable for Open-X methodologies, this paper presents an assessment concept for evaluating each PLC stage regarding their Open-X capabilities and possible constraints. To illustrate the utility of the assessment concept, this paper identifies two PLC stages which demonstrate exemplary capacity for Open-X methodologies.

Keywords Open-X methodology · Open innovation · Product life cycle

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1 Introduction

Open Innovation opens a company's innovation process to its environment [1]. This means new innovations are no longer solely created in isolated R&D departments but with the support of actively integrated customers, suppliers, other companies or even competitors. We can distinguish between two possible kinds of innovations according to the flow of information: (1) the outside-in innovation, which uses external knowledge for the development of new or improved products, and (2) the inside-out innovation, which specifically gives information to the environment to enable external innovations [2].

Till this point, the research in this area has mainly been driven by economists such as Henry Chesbrough, Eric von Hippel, Ralf Reichwald, Frank Piller and others. These economists normally stopped short of considering the transition from the economic concepts to the technical realization. Engineering research started filling this gap by operationalizing and adapting those concepts in practical use [3, 4]. Currently the main research focus is on the early stages of the Product-Life-Cycle (PLC) such as the Open-Product-Development.

Thus far, examinations of the entire PLC from the perspective of engineering science have been rudimentary, at best. Howard mentions the relevance of considering the entire PLC from the view of the design stage by, for example, collecting information concerning later stages such as disposal [3]. Though the information relates to all stages of the PLC and can be gained from each stage, it is mainly used for the development of new products—which means an application in the early stages like concept or development. An application to existing products—in later PLC stages—is widely neglected, as illustrated in Fig. 1.

In the eyes of the authors this is a huge deficiency: although the early stages are of great importance in determining the costs of later stages, as shown in Fig. 2, these costs primarily appear in later stages. Concepts like Systems Engineering already consider the whole PLC but also only from the point of development.

Mistakes made in early stages might lead to high (changing) costs in later stages. Also, varying customer needs, changing markets or new technologies can

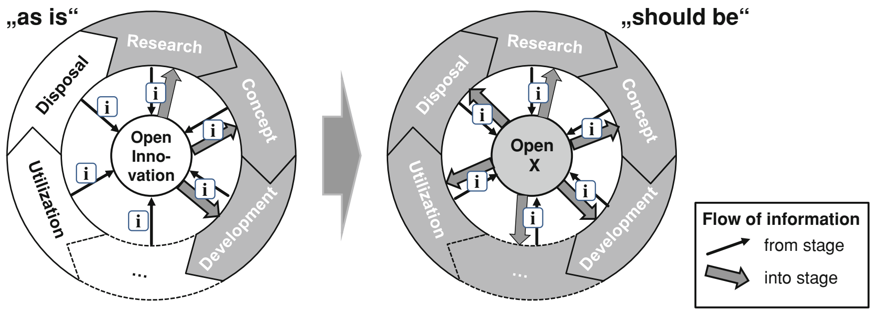

Fig. 1 Application of gained information in every stage of the product-life-cycle

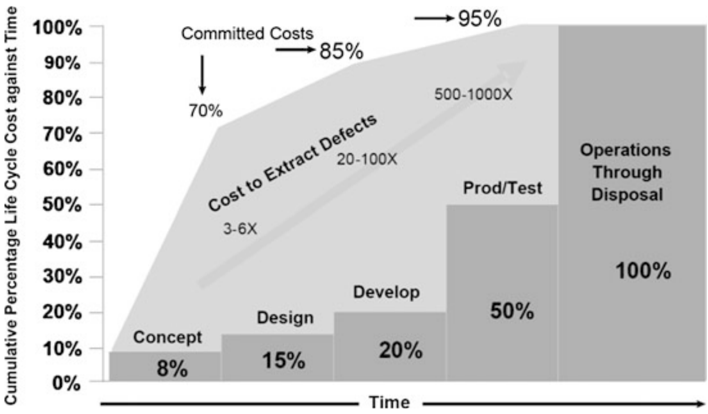

Fig. 2 Committed life cycle cost against time [6, Figs. 2–3]

cause product adoptions. With this, Open-X methodologies bear the potential for near-term improvements in later stages: for example Open-Utilization can help creating product updates or new services. As shown in Fig. 1, information which is gained all over the PLC should be used not only in early stages but across the entire PLC.

However, each stage has its own characteristics and requirements to Open Innovation methods: the range from the internal information being published, the retaining of intellectual property, supporting processes inside the company, and so on. Braun stresses the importance of defining in advance which stages of the innovation process are possible, advisable or necessary to be opened [5]. Due to the complexity that arises when all characteristics are considered, this is not a trivial task. Hence, there exists the need for a method to determine those aspects. This paper presents an evaluation sheet as part of an assessment concept to examine the characteristics of each stage of the PLC and analyze possible points of application for Open-X methodologies.

The following chapter introduces the relevant stages of the Product-Life-Cycle considered in the Open-X approach.

2 The Product Life Cycle

This section briefly presents the single stages of the Product-Life-Cycle (PLC). To design the Open-X approach on a workable foundation it is based on the Systems Engineering concept and its PLC considerations [6]. The Systems Engineering approach is widely accepted and used in research as well as in industry. Thus, the following examination is oriented towards the stages considered in Systems Engineering (shown below).

In this context a product also includes Product-Service Systems which consists of a technical product part and an intangible service part [7], as we expect a broad understanding of a product to support our PLC analysis. Figure 3 illustrates the enhancement of Chesbroughs' innovation process funnel [1] towards an entire Product-Life-Cycle view. The inner cycle symbolizes the company with its PLC stages and superordinate units such as organization, (long term) strategy and structure. The outer cycle illustrates the company's environment. Through the permeable borders innovations can be exchanged.

The following section gives a rough overview of the PLC. Due to spatial constraints the overview is restricted to half of the stages. For more detailed consideration please see the literature referenced in this paper.

2.1 (Product) Development

The purpose of the Development stage is to design a product that meets customers' requirements and is possible within the constraints of the company (e.g. available technologies, special production machines). In a classical innovation process the customer requirements are surveyed by the marketing department, preprocessed and transferred to the development department. This stage also constitutes strategies for integration, verification and validation of the designed product [6].

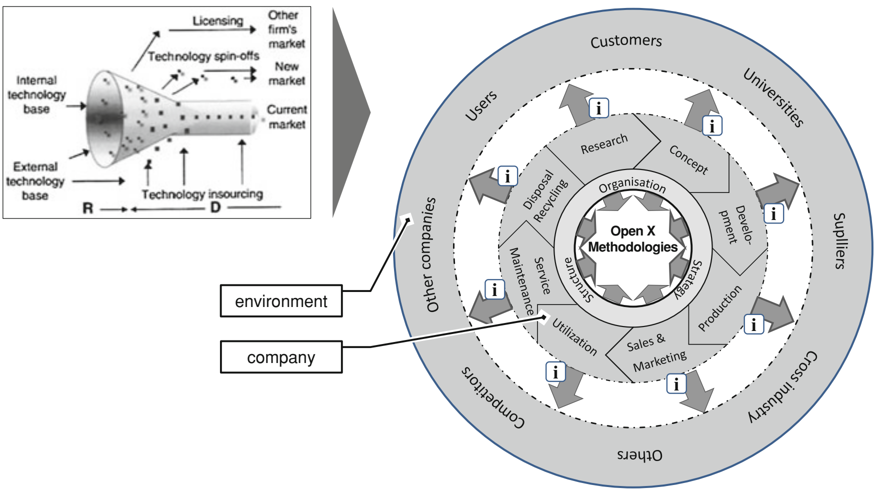

Fig. 3 Enhancement of open innovation towards the entire PLC (left figure after [1, Fig. 1.2])

2.2 Production

In the Production stage the previously designed product is manufactured, single components are assembled and the final product is tested. In some cases it might be necessary to modify the product to resolve production problems or enhance the product's capabilities [6].

2.3 Utilization

"The Utilization Stage is executed to operate the product, to deliver services within intended environments and to ensure continued operational effectiveness." [6]. To enhance the capability of a product upgrades might be designed and applied

2.4 Disposal and Recycling

This stage disposes of old products in an economic and ecofriendly way and provides supporting services. Normally planning for disposal is already part of the concept stage [6]. However, in the case of old products manufactured decades ago the disposal process can be challenging and expensive.

3 The Open-X Evaluation Sheet

As shown above, each stage has a different task in the innovation process, including different players, processes and resources. Thus, methods which are applicable for one stage might not fit to another due to specific characteristics and constraints. It is therefore not possible to give a blanket statement about the applicability of Open-X methods, demonstrating the need for a systematic analysis and assessment of each PLC stage.

The following section describes the structure and setup of the developed Open-X evaluation sheet as part of an assessment concept. The primary goal is supporting research to find possible points of application for Open-X methodologies and potential research areas. In a second step the evaluation sheet can also be used in industry for analyzing the potential benefits and threads of opening a specific PLC stage.

The sheet consists of five main categories which were determined by literature review and projects' experience. They are: actors, classification of innovation, effects, issue and provided information, and risks. Each main category comprises several first- and second-level subcategories, which are explained in more detail below. In this paper we focus on the outside-in innovation process due to its strong awareness in research and industries [8]. Our future considerations will deal with the inside-out innovation process as well.

3.1 Actors

This section describes: who can participate, how they can participate, how a company can access them and if there is a critical number of participants.

3.1.1 Participants

This category classifies the kind of external partner participating in the Open Innovation process in this stage of the PLC. It can be distinguished between random persons or experts [9]. It further differentiates between private persons and institutional participants as well as between direct or indirect customers or suppliers of the regarded company [10].

3.1.2 Accessibility to Participants

Closely linked to the kind of participants is the question of their accessibility. Is it sufficient to involve a random group of people or is it necessary to invite special groups with specific expertise, like Lead Users who might be determined in advance? [11].

3.1.3 Required Number of Participants

Depending on the issue and the stage of the PLC, either a small or a large number of participants might be suitable, which also directly affects cost and complexity.

3.1.4 Type of Participation

Depending on the issue, participants can support the innovation process with ideas/information, services or even products.

3.2 Classification of Innovation

This section characterizes the types of innovation the opening of a specific stage can enable.

3.2.1 Target of Innovation

The innovation project can aim at a product (e.g. a new or improved product), a process (e.g. an improved distribution process) or an entire business case (e.g. the decision to enter a new market) [12].

3.2.2 Value Gain/Main Objectives

This section describes potential objectives for Open Innovation in this PLC stage. The corresponding Open-X project could target market share (e.g. by modifying the product portfolio), production (e.g. by lowering the costs, more flexibility), better insights in products' application and social and environmental improvements (e.g. less emission).

3.2.3 Type of Innovation

Innovation can either be incremental or radical. Incremental innovations are related to small improvements of existing products or processes, whereas radical or breakthrough innovations go along with fundamental changes [13].

3.3 Effects

Opening one stage can also affect other stages and can influence the whole company itself. These effects are discussed below.

3.3.1 Effects on Other PLC Stages

This category classifies the effect on other PLC stages resulting from changes in the stage being opened. Normally changes in early stages will affect all following stages. But changes in later stages might affect preceding stages, e.g. changes in the Production stage might lead to modified product architecture.

3.3.2 Possible Side Effects

The effects can be further distinguished as internal effects (e.g. on company departments), external effects (e.g. a better PR) and the impact on the company's network (e.g. on the supply chain).

3.3.3 Financial Effects

Each PLC stage should be analyzed as to whether extra value can be added to the product in this stage and if it is possible to gain direct revenue from this stage [adopted by 3].

3.4 Issue and Provided Information

In order to gain potential innovations by Open-X, the company first needs to provide some information by itself. The kind of information and its preparation is classified in the following.

3.4.1 Effort for Issue Definition

This section describes the effort and difficulty to define a suitable issue for an Open–X project and the amount of corresponding information needed to be published to ensure a sufficient result from a project. It also determines the kind of information, e.g. just text, photos, special data or a combination of them.

3.4.2 Complexity of Issue/Task

The complexity of an Open-X issue determines the kind of participants (e.g. a random crowd or a group of experts). Thus, it is essential to analyze the complexity of potential issues in each PLC stage.

3.4.3 Effort for Evaluating Gained Information

During the Open-X project a large amount of ideas and information will be collected. To operationalize them they need to be analyzed and categorized, and have useless items filtered out. Depending on the issue the evaluation can be carried out by a "random" employee, special experts, by a jury, or even by the participants themselves.

3.4.4 Transparency and Accessibility

In each PLC stage the quantity and quality of the information provided to the participants can differ along with the accessibility of information amongst the participants. For example, when considering critical parts or processes it might be expedient to publish little information and filter information gained by participants before giving them to the other participants.

3.4.5 Interaction/Feedback

This section deals with the question of whether interaction and feedback between the participants themselves as well as with the company or special experts might improve the outcome of the Open Innovation process [14].

3.5 Risks

This section describes potential risks that can occur by opening a PLC stage, which should be considered in advance.

3.5.1 Data Security/Knowledge Drain

This category defines the expected amount of information needed to be published to get a sufficient result. It also determines the degree of necessary confidential information.

3.5.2 Replicability of Accessible Information

This aspect deals with the question of whether participants or competitors can use the information provided by the company and the participants for their own business, or even for rebuilding the regarded product or system [3].

3.5.3 Strategic Risks

Here, possible strategic risks are determined. Risks include the drain of knowledge (company's knowhow as well as information from the Open-X project), the partial loss of system's control to participants or competitors [10], uncertainty of gained information, among others.

3.5.4 Possible Operative Barriers

To ensure the success of an Open-X project it is necessary to identify and classify possible interferences with the daily business and its impact on the company's processes and structures.

4 Examples: Open-Product-Development and Open-Disposal

To illustrate the concept and demonstrate its practical use, the Open-X evaluation sheet is applied to two examples from different PLC stages. The first one is located in the Development stage and is based on the experience from industrial idea contests. Here, two companies had developed new pre-products and were looking for innovative fields of application. For this they published a description and photos of their pre-product on an idea contest platform on the internet with the proposition: "What would you make out of…?" Here everyone was able to register and post their ideas.

The second example is generic and located in the Disposal stage. It considers the disposal of an old cargo ship designed and manufactured decades ago without caring about retirement or recycling issues. In this case, the fictitious shipping company looks for efficient, economic and ecofriendly ways to retire the old ship.

The choice of an early and a late stage will serve to emphasize the different characteristics of each stage. Due to space constraints just a part of the categories can be presented in detail (Table 1).

5 Discussion

As we can see, the Open-X methodologies bear great potential. For Open-Development this potential has already been verified by practical utilization in several industrial projects. Open-Development methods support the innovation process not only by gaining ideas for new fields of application, as shown in the prior example, but also with ideas for future products based on real stakeholder needs or solution ideas for challenges during the development process. In the case of retirement, Open-Disposal can contribute to gather both ideas to dispose and recycle an old product (e.g. a cargo ship) in an efficient and ecofriendly way, and maybe also support in becoming acquainted with specialized disposal-companies which offer corresponding services for the whole product or single subsystems.

Additionally, the evaluation sheet exposes similarities but also differences between the two Open-X stages. While in the case of Open-Development a large group of participants without much expertise in a specific field can participate, Open-Disposal requires a group of experts which on the other hand might be smaller. The kind of the expected innovations also differs: for Open-Development, the focus is on new products or business cases. Here, innovations are mainly gained in the form of ideas, drawings or first technical concepts. In contrast, Open-Disposal aims for process innovations in the form of ideas/information for recycling/disposing old existing products, or the consideration of services offered by participants. The type and amount of information provided by the company is also different in each case: when collecting ideas for new applications of a building

Table 1 Comparison of open-development and open-disposal

Category	Open-development	Open-disposal
Actors		
Participants	Due to the low complexity of the task no special expertise is required. Thus, amateurs as well as experts can participate	The complexity of the task requires special expert knowhow which usually only a minority of amateurs possesses
Accessibility to participants	Since the task can be performed by a random crowd the accessibility is relatively easy. This can become more difficult with an increasing complexity of the issue (e.g. solutions for technical problems)	Due to the required expertise, the number of potential participants is limited, which also complicates the accessibility
Type of participation	Primary participants provide ideas for (in this case) possible applications in the form of text, drawings, etc. They might also act as potential partners for realizing their ideas	In this stage, it is likely that participants not only provide suggestions for disposal steps but also for services (e.g. "If you prepare component A and B in a specific way, my company can dispose of it and would even pay you money for these components")
Issue and *provided information*		
Effort for evaluating gained information	Due to the low complexity of the task, the contextual evaluation of the received ideas is relatively easy. Challenges can arise out of an usually high number of ideas and diversity of content and formulations. In some cases, an evaluation by the participants themselves might also be possible	Though the amount of information is smaller, the more complex content increases the evaluation effort required. Normally, an internal expert group needs to perform detailed analysis and calculations to determine whether suggestions are applicable and economic
Risks		
Data security and knowledge drain	The amount of provided information is medium: though the most important properties of the pre-product needs to be published, these might be in a rough level of detail. Additionally no information regarding the manufacturing process is required. This also limits the risk of knowledge drain to a medium level: other companies might adapt some ideas to similar products of their own but they do not gain insights into the production process itself	The disposal of an old and complex product requires a high amount of information and high level of detail, e.g. technical drawings, photos, visits, etc. Due to the age of the product and the contained technology the risk of knowledge drain usually is relatively low. Exceptions might be "top-secret" products like military systems

(*Source* own data)

material or other products, rough information about properties and perhaps some photos are sufficient. For disposing of a product more and detailed data is necessary, such as detailed descriptions, photos and technical drawings. From these examples it is clear that the Open-X methodologies as part of Open Innovation, containing method- and tool-sets, need to be adapted to the characteristics of each stage. At this, the Open-X assessment makes a great contribution to determine these characteristics and the potential and potential barriers of an Open-X project.

6 Conclusion and Outlook

As described in the discussion section, Open-X methodologies bear great potential for a sustainable innovation process. The presented Open-X evaluation helps research to analyze the characteristics of each PLC stage and determine potential research areas and constraints for new methods and tools. In a second step, industry can use it to improve their innovations processes. With this, two levels of focus are possible: (1) a company focus: which PLC stages can be opened, which benefit can be expected doing this and which constraints need to be considered? and (2) a product focus: at which stages of the PLC can the product gain which input?

The illustrated verification of the Open-X evaluation on two PLC stages showed the challenge on finding the right combination of categories and a convenient level of detail. However, despite the first successful results the long-term add value will manifest after multiple applications in practice.

Hence, this paper lays the foundation of a holistic approach to utilize the potential of Open Innovation for the entire Product-Life-Cycle. In the next step we will apply the evaluation sheet to the remaining PLC stages and analyze their potential for Open Innovation. We will also refine and further improve the evaluation sheet and enhance it to inside-out innovations. To ensure applicability, the Open-X evaluation will be verified in further industrial projects. Finally, based on the evaluation results we will develop efficient Open-X methods for each PLC stage.

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