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Integrating product and technology development: A proposed reference model for dual innovation

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Abstract

Although dual innovation projects, defined in this article as the concurrent development of products and technologies, often occur in industry, these are only scarcely supported methodologically. Limited research has been done about dual innovation projects and their inherent challenges (e.g. managing dependencies) and opportunities (e.g. streamlining development). This paper presents five existing reference models for technology development (TD), which were identified via a systematic literature review, where their possible integration with product development (PD) reference models was investigated. Based on the specific characteristics desired for dual innovation projects, such as integrated product development and coverage of multiple development stages, a set of selection criteria was employed to select suitable PD and TD reference models. The integration and adaptation of the selected models has led to a proposed integrated reference model for dual innovation that is currently being instantiated in the context of an ongoing action research project.

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Keywords: product development; technology development; concurrent engineering; reference model; technology readiness level

1. Introduction

When studying the domains of technology- and product development, there are several possibilities regarding the order in which they occur. One situation is that technology development (TD) takes place before product development (PD), after which the developed technology is applied in PD. It can also occur that a PD project is initiated, only to discover that the concept is not feasible with existing technology. In such situations, it can be decided to halt the development of the product until the technology has been developed, or the development of the product can continue alongside the development of the technology. In the latter case, the result is the concurrent development of a new technology and product. This situation is named dual innovation by the authors and is illustrated in Figure 1. Innovation is defined here as *the process of making changes, large and small, radical and incremental, to products, processes, and services that results in the introduction of something new for the organization that adds value to customers and contributes to the knowledge store of the* organization [1]. Dual innovation is defined here as *the simultaneous innovation of a product and a technology to be applied in that product*. A possible expansion would be the additional development of a new market, resulting in triple innovation. The definition of technology that is used here is the

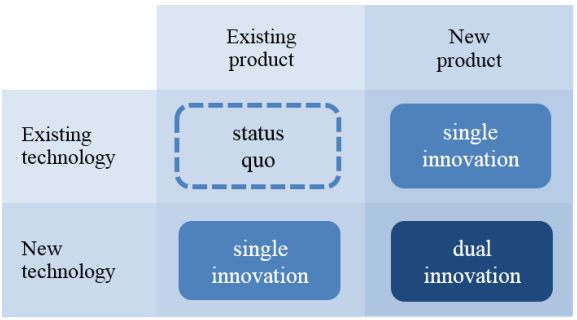

Fig. 1 The concept of dual innovation

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one given by Burgelman, Christensen and Wheelwright [2], namely: *"The theoretical and practical knowledge, skills, and artifacts that can be used to develop products and services as well as their production and delivery systems."* In other words, technology development supplies necessary input for product development.

While there has been much attention on cross-functional integration over the last decades, TD appears to have largely been kept out of the scope. As a result, while the metaphorical walls within the PD process have been taken down, the wall between technology- and product development often remains. Nobelius [3] concludes that this is because of the inherent difference in uncertainty and complexity between technology- and product development. Schuh and Apfel [4] argue that the number of companies that separate technology- and product development is actually increasing, because the timelines and levels of urgency are very different. Drejer [5] confirms that different time horizons are often used in these processes and adds that the two process *"speak different languages"* because they operate from very different angles. Separating the two development tracks makes it possible to plan product development more accurately, allowing for more stable product launch plans.

In the situation where a product concept sparks the need for a new technology this would mean halting the product development until the technology is developed, causing delays. As an alternative, the PD can be continued concurrently with the TD. This requires attention for the proper integration between the two. A lot of attention has been given to the integration of technology- and product development in literature. For example, Drejer [5] classified over 100 integration models to three dimensions of integration: activities, aspects and time horizons. These models focus on specific aspects of technology- and product development integration, posing questions to the decision makers. The interface between technology- and product development has also been given attention in research, for example by Schuh and Apfel [4], Jacoby et al. [6] and Lakemond et al. [7]. However, the existing research is focused on a fairly detailed level, discussing specific aspects of integration, such as a technology transfer moment, and tools that can be used. In addition, the attention for dual innovation is limited.

In practice, different degrees of integration between technology- and product development exist, ranging from separate development departments with a formal handover process to integrated teams that work on both types of tasks simultaneously. Nobelius [3] studied these two extremes in a case study, concluding that each approach has advantages and disadvantages. A separate TD department is often capable of delivering high quality results within the budget. However, they depend on a formalized knowledge handover. TD teams that also work on PD projects generally have more trouble working within budget. However, the result is often better suited for application within PD and no formal handover is needed, since many informal transfers occur throughout the development.

The specific situation of dual innovation has not been extensively investigated in literature. However, based on its characteristics, it may be expected to pose a unique set of inherent opportunities and challenges. Concurrent development of both the technology and the product might benefit from a high amount of flexibility and may allow for a large amount of optimization from both ends, which could result in an optimized solution. The potential to streamline the development may also exist, where both tracks work towards the same goal and focus on what is needed for implementation. The potential flexibility of dual innovation may also result in challenges, for example related to knowledge transfer, project management and decision making. This may be further complicated by interdependencies between the two development tracks. There could also be trade-offs between the technology and the product, which could put a high pressure on good decision-making.

A large amount of PD reference models exists. The definition of a reference model by Costa et al. [8] is used here, namely: *"A generic process model of a specific domain. … A representation of business processes containing best practices of an application area, which have a set of generic guidelines to be adapted for use in various contexts"*. A recent review in literature identified at least 124 PD reference models [9]. While some models indicate a link between technology- and product development, no reference models for dual innovation were found. This article aims to develop a reference model for dual innovation projects, which is meant to tap into the opportunities offered by dual innovation while providing support to deal with its challenges.

2. Methodology

The methodology adopted in this research consists of seven steps (Figure 2).

- Step 1: Systematic literature review of TD models. A search for journal articles and conference proceedings describing the proposition or application of a TD reference model was done in Web of Science, Scopus and a university-developed global search engine using. A search string based on combinations of the following keywords was used: technology, manufacturing, hardware or production, and development or innovation, and method, approach, model, reference model or process. The selection process consisted of reading the title and keywords, reading the abstract,

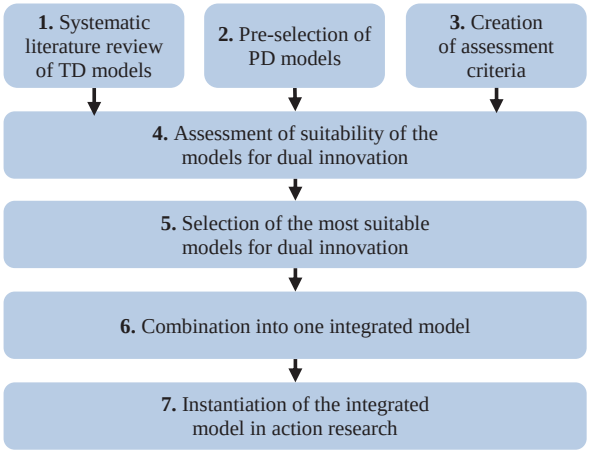

Fig. 2 Methodology steps