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## Commercialization within advanced manufacturing: value stream mapping as a tool for efficient learning

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### Abstract

Due to the recent drop in oil prices and high environmental dynamism, organizations delivering in affected markets need to identify ways to reduce time to market (TtM) and cost of non-quality (CONQ) of their commercialization processes, in addition to pursuing and developing new markets. In order to survive over time, organizations need to manage knowledge for both exploitation and exploration, utilizing existing competencies and acquiring new ones. This paper discusses the study of a multinational organization's commercialization process of two large and complex projects and their R&T/D (research and technology/ development) and NPI (new product introduction) processes. The two projects are chosen as they represent two ends of a continuum scale of exploration and exploitation. The first project relies primarily on *new* knowledge, capabilities and skills and the second on *existing* ones. The data is collected through an exploratory case study based on observation of a two-day value stream mapping (VSM) workshop conducted for each of the projects. In addition to the case study, the analysis in the article is based on archive data such as emails, hour bookings from the organization's ERP-system, technological and financial reports, presentation material, and internal and external announcements. This article's novelty is derived from the depth of the insights provided in the case and the rich and detailed data gathered. The findings provide a review of the operational challenges and best practices for reducing TtM and CONQ of the commercialization process in the context of advanced manufacturing.

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### 1. Introduction

A decisive part of an innovation is the commercialization or industrialization process of the product or service. The time where organizations could invest and build *technology fortresses with high barriers of entry* are gone [1]. This stresses organizations to reduce their *time to market* (TtM) and their *cost of non-quality* (CONQ) of *new product introduction* (NPI). Organizations need to continuously improve and design their products and services for service, cost and manufacturing [2, 3, 4]. *Advanced manufacturing* is the application of novel technologies, and a term describing manufacturing that adds a high degree of value in the production process, typically associated with complex products. Other characteristics comprise high cost base, degree of knowledge creation, abstraction and absorptive

capacity, advanced capabilities and technology, and a need for agile and flexible processes. The advanced manufacturing industry is also characterized as *first movers* in terms of technology, utilizing new often disruptive manufacturing tools. Such new tools and technologies within manufacturing technology have also been assigned the German term *Industrie 4.0* [5]. Advanced manufacturing industries can be found in several places around the world, as in Norway. Such industries are typically networks of many different – often complementary organizations delivering to markets with similar customer requirements. The actors are often close in geographical proximity; they have known capabilities and proven past history; and they compete locally for recruiting the best employees and skills, which has raised the cost base. With the recent environmental dynamism caused by the drop in oil prices and with the current market situation, this calls for cost reduction initiatives and new practices.

The task of creating profitable growth and long-term survival of organizations has been described in management literature as *organizational learning* through exploration (includes: search, variation, risk taking, experimentation, play, flexibility, discovery, and innovation) and exploitation (includes: refinement, choice, production, efficiency, selection, implementation, and execution) by March [6: 71]. March [6] introduced the underlying paradox of exploration and exploitation of *the balancing hypothesis* and scholars have given extensive attention to the paradox in this field of inquiry. The phenomenon of balancing exploration and exploitation behaves differently on different units of analysis, which has important implications for the assumptions made. Short term is overemphasized over long term since returns from exploration are: positive, proximate, and predictable and returns from exploitation are: uncertain, distant, and often negative in short terms [6: 85]. However, organizations need to manage both exploration and exploitation in order to survive over time, but it is problematic to engage in both.

Levinthal and March [7] refined March's [6] balance statement from *both*, to exploitation to a minimum and exploration to a maximum. They argued that economic models had been developing without considering behavioral assumptions and found that behavior was also biased, and that becoming experts had a feedback-loop that reinforced a given behavior, thus becoming less able to adapt to changes in the environment. They also found that organizational techniques are problematic. The problems encountered are difficulty in transferring individual learning to organizational learning, and in cross-functioning and unit learning.

Much is understood regarding how balance is achieved and implications of balance. However, few empirical studies have looked into the operational sides of managing the transition from exploration to exploitation, or put in this study's context the transition from new product introduction to a fully commercialized product. New insights in this field will be of importance in efficiently bridging the gap between invention, conceptualization and commercialization. Since differentiation is related to exploration and cost reduction and elimination to exploitation, there is a tension between the organization's need to achieve reduced cost and time of their NPI and such processes' inherent need for *slack resources*. Such tension leads to the following problem statement and this study's focus: *how do organizations successfully commercialize complex product innovations, and manage the transition from exploration to exploitation?*

The overall objective of this study is to provide insight into the operational side of how companies can manage the commercialization of new technology and complex products within the advanced manufacturing context. The motivation for this study is based on the case company Rolls-Royce Marine's need to reduce cost and time of its NPI processes to provide an overall reduction in CONQ and TtM for its fully commercialized products. This study follows two major reviews for *value stream mapping* (VSM) of two selected NPI projects, representing two ends of the continuum of exploration and exploitation.

## 2. Theoretical framework

Since there is a continuous need to move products faster to markets, organizations also need to continuously develop their NPI processes [8]. However, Griffin also stated the importance of understanding the current cycle time of the processes before changing them, in order to have a baseline control on the expected effects of the planned change. This study elaborates such understanding by studying the value stream of two NPIs, and identifying points of improvement and acknowledges best practices in current processes.

Different schools of thoughts in management literature conceptualize exploration and exploitation differently and argue for exploration and exploitation as two ends of a continuum [6, 7, 9] or that they are two orthogonal and independent activities [10]. Gupta et al. [11] argued that exploitation and exploration are mutually exclusive, continuous within domains, and orthogonal across domains. This study agrees with the view that the distinction is a matter of degree rather than kind. The relationship between exploration and exploitation is difficult to disentangle, since they have inherent trade-offs. Such trade-offs are rooted in the competition for scarce resources, overemphasizing immediate and certain versus remote and uncertain outcome and the inhabitation of experimentation of existing routines [6]. Since organizations have the tendency to exploit over time, the solution is to explore more, pushing long-term performance. Siggelkow and Rivkin [10] show that organizational structure matters and trying to explore as much as possible can backfire at lower unit levels. Much of the research on exploration and exploitation has identified antecedents [12, 13]. They can be grouped in three categories: environmental (dynamism, shocks, competitive intensity, and appropriability regime), organizational history (absorptive capacity, slack resources, organizational structure, culture, size, and age), and behavioral (risk aversion, performance feedback, and past experience) [14]. In addition to the questions regarding definition and the continuum versus orthogonal issue, Gupta et al. [11] identified two additional key questions related to exploration and exploitation. Whether balance is achieved simultaneously or sequentially; and whether companies should do both or specialize in one?

Lavie et al. [14] identify four approaches for achieving balance. The first is ambidexterity, the simultaneous pursuit of exploration and exploitation and organizational separation. Benner & Tushman [15] argue for ambidexterity and measure exploration and exploitation along a continuum and find that firms' ability to maintain search and exploration is difficult, and challenged by process management. Raisch et al. [16] argue for managerial attention to achieve ambidexterity and balance through organizational separation and integration of internal and external knowledge. This requires dynamic management processes that need to resolve the tension between differentiation and integration, both at organizational and individual levels. One challenge with such approach is that the balance challenge can be resolved at one level, only to find its way to the next level in the organization. Also, there is the challenge of re-integrating the separate units leveraging new knowledge created through exploration and utilizing it

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