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CHALLENGES IN MANAGING NEW PRODUCT INTRODUCTION PROJECTS: AN EXPLORATIVE CASE STUDY

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Abstract

In today's market conditions, manufacturing companies are under pressure to constantly launch new products or product variants to the market in short intervals. The project management of new product introduction therefore play a significant role in the success of new product development. The existing literature covers a wide range of issues and disturbances in the product introduction process in different industries. However, little research exists on the management of new product introduction projects from a project management perspective especially from the viewpoint of production. Based on a case study at a manufacturing company, this paper examines the challenges in managing new product introduction projects in the production organisation. The study identified nine key challenges in the management of new product introduction projects which are associated to the resources, time-readiness and schedule, gated administration, ways of working, communication and time-sharing, learning, business case, co-ordination and alignment, and competences.

Keywords: New product development, Project management, Product introduction, Industrialisation, Organisation of product development

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1 INTRODUCTION

Fierce global competition is forcing manufacturing companies to increase the rate of new products, variants or innovations are introduced to the market. The goal is to rapidly launch cost-effective, innovative products faster to market with highest quality and features. The companies that can handle these demands efficiently can surely gain an important competitive advantage (Carrillo and Franza, 2006). In this regard, product introduction, the final phase in the product development process and known as the industrialisation process (Berglund et al., 2012; Subier et al., 2013), has become essential for numerous reasons. For instance, the product introduction phase has a considerable influence on the time to market and the quality of a product in a new product development (NPD) project (Adler, 1995). Companies which can efficiently manage product introduction can realise a shorter time to volume and a viable cost-effective production system with fewer disturbances (Almgren, 1999; Fjällström et al., 2009). Hence, effective planning and management of new product introduction is crucial for the successful new product development.

Product introduction involves activities related to both product and production system development which demands closer cooperation and integrated management approach between "product design and engineering" and manufacturing (Dekkers et al., 2013). Research has provided numerous methods to support this integrated management approaches (Dekkers et al., 2013) such as concurrent engineering, design for manufacturing and assembly, quality functional deployment, product platforms (e.g. Harland and Uddin, 2014), and flexible Stage-Gate models (e.g. Cooper, 2009).

Moreover, there is a growing trend in manufacturing companies to involve production and operations organisations early in the complex NPD projects (Lakemond et al., 2007; Ruffles, 2000), even in the feasibility and pre-study phases. Further, companies have been initiating separate project management organisations within production and operations organisations to prepare better to support NPD projects and to address project novelty in operational processes (e.g. Akinc and Meredith, 2015; Browning and Heath, 2009; Chirumalla et al., 2016). For example, a NPD project with a high degree of newness or novelty can urge production organisations to internally start several investment projects, e.g. purchase of a new production equipment or a new assembly line, to cope with the modern technology and features in the product. As a result, production organisations are increasingly considering product introduction and industrialisation as separate projects, which usually run parallel with NPD projects.

There is a growing body of literature addressing issues, success factors, and challenges of project management in NPD projects (Kach et al., 2012; Munthe et al., 2014; Dooley et al., 2005; Jepsen and Eskerod, 2009; Dröge et al. 2000; Tatikonda and Rosenthal, 2000; Sommer et al., 2014). For instance, Kach et al. (2012) analyzed underlying factors for the success of a high novelty innovation project and found three factors as central, namely, visionary leadership, project momentum, and team collaboration. Sommer et al. (2014) identified four root challenges for the successful integrated product development, namely lack of resource management, lack of knowledge management in project governance, lack of fitting project model in projects, and lack of education and training of human resources. However, the theory of project management in operations is limited (IJOPM special issue, 2015), especially in the context of new product introduction. Most studies on product introduction or industrialisation focus on the disturbances, risks, challenges, and influence factors in the process (e.g. Javadi et al. 2013; Surbier et al. 2013; Berglund et al. 2012; Bellgran and Säfsten 2010) rather than on the project management.

Therefore, the purpose of this study is to identify the key challenges in the project management of new product introduction projects. Based on explorative case study in a largest company in heavy-duty vehicle industry, the paper presents the types of new product introduction (NPI) projects and challenges in managing these NPI projects.

The remainder of this paper is organized as follows. The next section provides background to the NPI process and challenges in managing NPI projects. The third section presents the research method. The empirical findings are discussed in the fourth section which is followed by some concluding remarks.

2 THEORETICAL BACKGROUND

2.1 New product introduction process and project types

The product introduction process is defined as "transferring from engineering design to production including those activities required to make the product manufacturable and to prepare production" (Bellgran and Säfsten, 2010, p. 233). Several researchers viewed the new product introduction (NPI) process in distinct phases (e.g. Berg et al., 2005; Fjällström et al., 2009; Johansen, 2005; Ruffles, 2000). For instance, Berg et al. (2005) described the NPI process in three main phases: test production, pilot production and production ramp-up. Fjällström et al. (2009), Ruffles (2000), and Johansen (2005) viewed the NPI process in an extended manner, including the phases such as conceptual study, engineering prototypes, pilot production, pre-series production, and production ramp-up.

Several studies proposed planning and management methods to support the NPI process. Berglund et al. (2012) suggested that the standardization of work procedures, materials and parts can simplify the conceptual study and the entire NPI process. Almgren (1999) classified degree of newness of the product and of the production system on a three-point scale: new, modified, or existing, to propose different final verification scenarios for production ramp-up. This classification model could be a starting point for judging which number of resources, time and effort would be needed to successfully carry out a production ramp-up with a certain complexity. Terwiesch and Bohn (2001) emphasized the importance of learning and education in the NPI process to deal with the complex problems. Further, researchers asserted the early involvement of production in the conceptual study phase to reduce non-conformities between products and production systems in later phases (Adler, 1995, Lakemond et al., 2007, Ruffles, 2000). Moreover, Säfsten et al. (2006) and Carrillo and Franza (2006) emphasized the importance of preparatory activities in the earlier phases of the NPI process in facilitating the production ramp-up and reducing disturbances during the early production.

Wheelwright and Clark (1992) argued that defining and mapping the diverse types of development projects is a first step in creating an aggregate project plan. According to them, defining project classification provides useful information about how resources should be allocated. Using the construct of degree of change in the product and in the manufacturing process, they have divided projects into five types – derivative, breakthrough, platform, research, and advanced development. Each of the project types require a unique combination of development resources and management styles. Such understanding of the categorization of projects helps managers predict the distribution of resources accurately and allow for better planning of projects over time. Slamanig and Winkler (2012) distinguished three diverse types of product change projects: incremental, platform, and architectural product changes. They found that the main challenges in managing new product introduction of these projects are associated to supply chain network and management. Further, Bruch and Bellgran (2014) proposed an integrated portfolio planning of products and production systems with four different levels of novelty in relation to advanced engineering within production system development: They are: 1) use of carry-over solutions from existing or earlier production systems, 2) improved existing production technology solutions already known to the company, 3) state-of-the-art production technology solutions not previously used at the company and finally, 4) development of unique production technology solutions.

2.2 Challenges in managing new product introduction projects

New product introduction is challenged by elevated levels of disturbances in various aspects of production (Fjällström et al., 2009), effecting production cycle times, outputs and the quality of products (Terwiesch and Bohn, 2001; Almgren, 1999). Fjällström et al. (2009), and Surbier et al. (2013) divided the sources of disturbance into seven categories: products, production processes, supply chain and logistics, quality, methods and tools, personnel and cooperation and communication. Berglund et al. (2012) stated that to accomplish the successful product introduction, the collaboration of different organizational functions and individuals in a cross-functional project team is essential. Other key factors to consider in the NPI projects to avoid critical risks are: early prioritizing, timing, and integration of the production system development in the product development project (Bellgran and Säfsten 2010; Säfsten and Aresu, 2002). Further, information management during the industrialization project has also been identified as critical for an efficient NPI process (Bruch and Bellgran, 2013). Javedi et al. (2013) found four challenges in the NPI projects of low-volume production systems. They include: knowledge

transfer from the projects into production, development of the work instructions, the need for a higher level of training of the operators and production system design, and the required tailoring of new products to the existing production systems.
Nihtilä (1999) found that cross-functional planning is a prerequisite for integration of R&D and production during early phases of product development. Dröge et al. (2000) identified four factors, which have impact on product development time and introduction time. They are: synergistic integration, supplier closeness, human resource management, and design-manufacturing interface. Further, Jepsen and Eskerod (2009) found that the current guidelines regarding stakeholder analysis in the renewal projects lack clarity regarding how to identify stakeholders and determine their importance and how to reveal stakeholders' expectations. Further, the application revealed that the project manager may not have the skills or the resources required to carry out the tasks involved in making the necessary inquiries. Sambasivarao and Deshmukh (1995), based on the literature review, identified a substantial number of issues in implementation procedures of advanced manufacturing technology projects. Some of the key issues include: allocation of responsibilities and tasks to departments, assess the required resources and ensure their availability, set the time-frame for the implementation, specify the essential relationship among departments, and educate and train the employees for specific needs. At a general level, Dooley et al. (2005) found that challenges in managing multiple projects are associated to alignment management, control and communication, and learning and knowledge management. Further, Munthe et al. (2014) found three management challenges of deviations in complex product development, namely component deviations, interface deviations, and concept and scope deviations.

3 RESEARCH METHOD

3.1 Case company

This study was performed in collaboration with one of the largest manufacturing plans of a global company, which develops, manufactures, assembles, and paints components for the heavy-duty vehicle industry. The company has more than 10,000 employees and in the last five years it has produced more than 40,000 vehicles per year, from more than 10 plants around the world, with over 400 dealers in 145 countries. The studied manufacturing plant (hereafter referred as the *case company*) was chosen due to having rich experience in managing a wide variety of types and sizes of NPI projects in production. The plant is also the core plant within the company for the type of components it produces. The case company recently reorganized and structured their process governance models for new product development (NPD) and production development projects. Previously, NPI is merely considered as a phase within a global product development process model, which is characterised as a waterfall model. To cope with the issues related to the time-to-market, quality, and cost, the production and operation organisation began to involve early in the new NPD projects, for instance from the feasibility study and pre-study phases, as shown in Figure 1. Hence, in the new governance model the product introduction process is a parallel process in the NPD project model since the feasibility study and it ran as a new product introduction (or industrialization) project in production as shown in Figure 1 in dark grey colour.

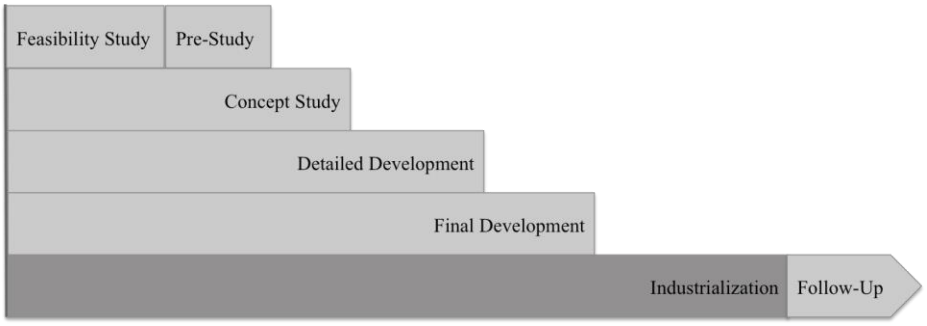

Figure 1. New product development project model used in the case company

3.2 Data collection and analysis

The case study method was employed as the overarching approach, because the study needed an in-depth examination of the actual practice in a real-life setting (Yin, 2009) for the purpose of developing theory. Data was collected through eight semi-structured interviews, formal company documents, and

workshops. The interviewees included a team leader and four project managers from the industrialisation department, and three project managers from the production development department. All respondents have more than 10 years working experience in the company. The average duration of the interview was approximately 60-75 minutes. All interviews were recorded and transcribed. After the interview, participants were asked to position their own projects in the Almgren's model (1999) three-point scale: new, modified, or existing, and to fill in the approximate percentage of newness for each of their projects both on the product and the production side. In addition, documents related to 22 ongoing projects in production were collected, especially the percentage of newness on the product and production side. Based on the collected data from the participants and the project documentation, all projects were positioned on a two-axis along three-point scales: new, modified, or existing. Based on the positioning, projects were grouped into clouds as shown in Figure 2 where each cloud represents a type of a project. Data from interviews were analysed using spreadsheets with a pattern-matching technique (Yin, 2009). First, all challenges relating to project management were identified and listed in spreadsheets for each participant. Second, similar challenges from all participants were identified and grouped them into patterns. In total, nine patterns were identified which were labelled as specific key challenges for managing NPI projects.

4 EMPIRICAL FINDINGS

4.1 Types of new product introduction projects

The case company typically runs projects at a component level and delivers to the machine projects. The analysis showed that from a production perspective there are mainly seven types of projects in relation to the NPI at the case company. Listed in the order of complexity, they are: 1) new-component projects with investment projects, 2) new-component projects, 3) insourcing projects, 4) update projects, 5) product-maintenance projects, 6) only-investment projects, and 7) improvement projects.

New-component projects with investment projects are associated with industrialising highly complex components in the plant, which demands employing new methods, processes, and solutions to produce the components that require, for example, new equipment, a new assembly line or assembly stations, or even a new production line. *New-component projects* are projects that are associated with industrialising the new components in the plant, including prototyping, pre-series, testing, and starting of serial production. *Insourcing projects* are projects that are associated with the products that were produced in another plant before, but are now introduced into the studied plant. *Update projects* are projects that are usually associated with the modified product that has consequences in the existing production system. *Product-maintenance projects* are projects that are associated with some minor changes in the product (i.e., raw material change or changes after start of production due to quality), which often requires minor changes in the production system. *Only-investment projects* are projects that are associated with the investments in improving the existing production system, for instance, making changes in existing cells that requires purchase of new machines, or buying new equipment for enhancing capacity. *Improvement projects* are projects that are associated with smaller improvements in the plant, for instance, rebuilding the equipment, and enhancing production process quality assurance. Figure 2 illustrates the position of on-going development projects and their types across the product newness and production system newness dimensions. Each cloud represents an approximate area related to a specific type of projects, which is defined based on the positions (i.e., cross-box) pointed out by the respective project managers and a team leader. As seen in Figure 2, both the new component projects with investment projects and the new component projects are positioned far in the top right corner, showing that project managers consider them as highly complex and higher in terms of level of newness, both from the product and production system perspectives. Some project types are positioned in multiple areas (e.g., update projects, investment projects) since characteristics of these projects vary based on the degree of, i.e., reusing existing parts/equipment/cells/lines, years of experience in producing/purchasing/assembly similar parts, and what has changed.

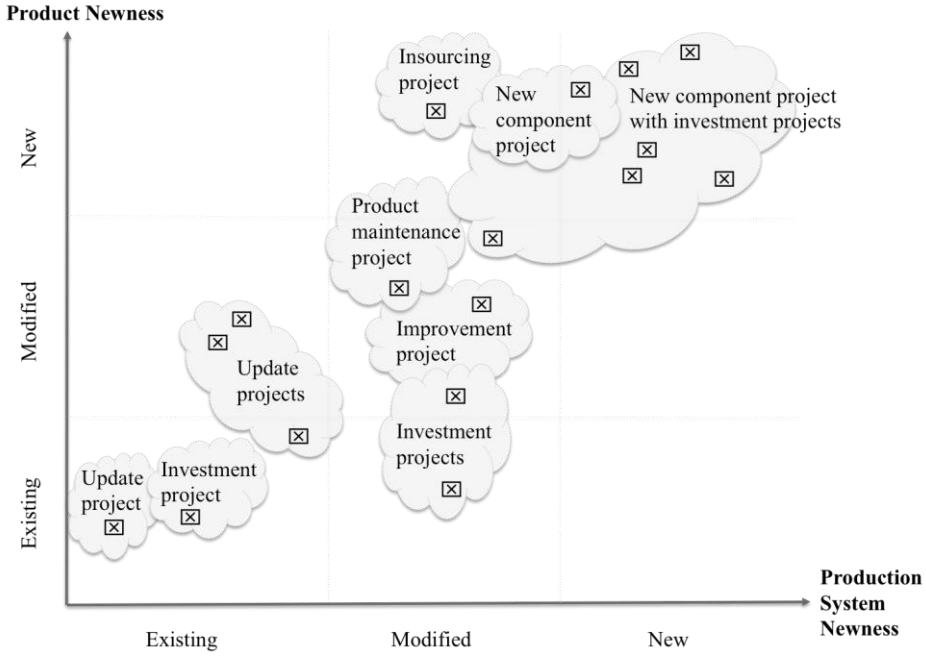

Figure 2. The position of different development projects and their types across the product newness and production system newness dimensions (Adopted from Almgren, 1999)

4.2 Key challenges in the management of new product introduction projects

The empirical analysis identified nine key challenges associated to the management of new product introduction projects: 1) designing and identifying the right resources, 2) time-readiness and schedule, 3) gated administration, 4) old ways of working, 5) poor communication and time-sharing, 6) missing learning opportunities, 7) defining business cases, 8) poor coordination and alignment, and 9) more projects with less competences. Based on the significance and criticality, the key challenges are mainly categorised into level 1 and level 2. Level 1 represents challenges 1 to 5 while level 2 represents challenges 6 to 9.

4.2.1 Designing and identifying the right resources for projects

All informants agreed that identifying the time for the right resources is a big concern in the management of product introduction projects. The project office places the number of hours needed from each department and factory in the initial planning phase. However, according to most informants, the system is often overloaded with numbers but doesn't consider the resources in detail. In most cases the same people are placed on many activities and given many tasks. Hence, the numbers becomes more of a wish list rather than reality. For novel projects, it is even more difficult to find the right resources, especially in the production-engineering and technology departments, as there are several projects at the same time. Moreover, the dynamic changes in the schedule cause late deliveries from the technology side, which eventually affect the planned time of resources in the project. For a new or novel project, the situation becomes quite complicated as it involves operations, production, software design, aftermarket, purchasing, verification, and validation. Such cases require a lot of help from the line organization, either in production, the design department, or purchasing.

In the case company, production does not have any specific project resources within the organization; rather, they have resources from the line organization. The line organization in production often focuses on on-going serial production or daily deliverables; they do not want to know anything too soon or too late. The new product might come to serial production in the next five to seven years, which may not be the main priority for the production line organisation. Hence, project managers for new product introductions often have daily conflicts with the line organization. As a consequence, NPI organisation must communicate clearly with the line organisation. In early phases, however, when conditions are uncertain, it is difficult to be clear. Furthermore, the NPI organisation does not always have the resources to start pre-studies within the production to investigate the impact of a new project on the production system. The NPI project team has the chance to influence in drawings when they receive specific

questions from the technology. But due to a lack of resources for special investigations, they do not have possibilities to influence on drawings. This affects the quality of the delivery time in the projects. There is a need for designing resources so as to estimate the time for resources based on the project's expectations.

4.2.2 Time readiness and schedule

Time readiness is the next challenge in managing projects. It is especially important at the end of the project, where, for instance, having the right production equipment, relevant articles, samples, and quality assurance is needed to industrialise the product in due time. This is particularly significant in the case of introducing new type of machining, assembly or other related new processes where the product and manufacturing processes are not enough matured. Before starting industrialization, most of the production activities and decisions have already been determined by the development department at the system level project. Hence, in the product introduction projects the agreed timelines are not really working at the component level. They need to update drawings or do calculations to know if the deviations are within the scope or not. In addition, there is no planned time for testing and verifications, so they do not have the time to test and learn from the failures.

Further, in complex new product introduction projects, there is a greater scope, engineering, and late changes, as well as late deliveries. The impact of these changes might not be visible from the product development perspective, but such changes might have a lot of impact on start of production (SOP) or from a production system perspective. With the involvement of different suppliers, it is challenging to ensure they work together to reach the planned time schedule. Moreover, it is difficult to plan a specific target for the entire schedule, which involves multiple projects, investments, and suppliers. A delay in equipment from one supplier might affect the entire schedule, including the start of production. This eventually affects the time-to-delivery to the machine or system level projects.

4.2.3 Gated administration

In the case company, the stage-gate models are used for all six types of development projects, from smaller to more complex projects. Though informants acknowledged that stage-gate models are important for project governance, as they involved budget and time planning, many also emphasised that gate reviews are often an administrative tool rather than supporting them in their work. If any project executed all its activities as described in the gated model, then gates can be a reflection and decision tool to assess the progression of the work in terms of cost, quality, and time. However this is not often reflected in practice with significant changes, constraints, and deviations in projects. Project managers are then forced to prepare to the gates even though the project does not cover all the activities. The question becomes: does gate review really add any value, or does it fulfil the intended purpose? Rather than having quality checkpoints, it can create obstacles for the project. Moreover, some informants also stressed that even after passing the gate it took considerable time to make decisions, as it has to go through different boards—e.g., the CPM, steering committee, and the technical board. In addition, some informants emphasised instances in which they waited for the gate to come in to continue their work in the project—even for the smaller projects. Hence, the fixed review gates in a time line could frustrate the managers. Further, the directives that are used for production development projects, such as investments projects, are unclear in conveying the main goals, expectations, time line, and deliverables. There are some instances in the case company where a few projects were stopped due to a lack of agreement on what was to be delivered.

4.2.4 Old ways of working

In the case company, the manufacturing readiness level (MRL) is not considered in the feasibility study and pre-study; it only considered the technology readiness level. Few managers pointed to examples where concepts in some projects were mature from a technology perspective, but not mature enough from a manufacturing perspective to be in a specific phase and gate. Similarly, the degree of newness is not addressed in a structured way in production compared to the technology organisations. In the case company, the technology organisation assesses the project's novelty from a design perspective at the machine project level. Based on this assessment, they divided the component projects into three size/scope classes. But the production organisation is not usually involved in making this decision. This could affect the way "makabilty" or "manufacturability" of parts is considered in the early phases. For example, laser-welding concepts can be very rare and expensive, which could enormously increase the

project cost during the industrialisation of the product. Furthermore, many informants acknowledged that setting up project in production is not really structured in the early phases in collaboration with the technology organisation. Even the production plants (i.e. line organisation) do not have any KPIs related to the new products, prototyping, pre-series, or other related product introduction goals. Rather line organisation is more focused on the daily deliverables and quality in production.

4.2.5 Poor communication and time-sharing

Communication with the line managers and the respective line organisation is a challenge for many project managers. It is often unclear how to prioritize product introduction projects. Hence, from the industrialisation project management perspective, it is very difficult to communicate to the line managers what needs to be done, when, and why. Many informants acknowledged that there are daily conflicts with the line organisation in terms of resources. One reason for this problem is that top management team does not consult all managers for a consensus when estimating time resources.
Line organisation is dealing with the day's issues regarding the products. The project issues are not specifically prioritised in the line management department. Another challenge in complex projects is communicating to the different departments in the factory when there is a need for input from many sources. According to informants, it is difficult to reach the relevant people to communicate the issues and needs of the projects. In most instances, it is hard to get enough time with every project member as they are occupied with a lot of work. For instance, the production engineers are not only involved in projects, but also in daily production, which is often a priority over product introduction project that might be in the production in two years.

4.2.6 Missing learning opportunities

It has been observed that learning from projects is not really happening in the case company. The issues that occur in one project are repeated in the following projects. The learnings are reported in the lessons learned documents and communicated informally during project level meetings. However, there is a lack of action in spreading the lesson and avoiding the same mistakes in the future projects from a long-term perspective. It also depends on the person responsible for capturing project learnings. At the beginning of the project, it is up to team members to consider earlier lessons learned. They can find the signed lessons learned reports in every gate, which is a new initiative in the company implemented for the past six months. The case company does not have a gate that says: let's read the lessons learned report from this project. The root cause of the problem is budget in terms of time and cost. In addition, many informants stressed that as an organization they are not effective in follow-up activities. There is often no reflection as to why a specific solution ended up like this or whether it would be possible to perform the activity differently.

4.2.7 Defining business cases

Defining the right business case is critical for managing product introduction projects. In the early phases there is often a lot of discussion about the business case, such as whether the company can do it on the existing machines or current equipment, or whether it could be a new start-up. Shall they fit in the factory in relation to the volume and so on or shall they go for the buy or the make? The project manager has to put a lot of time into defining the business case in the early phases. This requires a lot of material and documentation, approval by many managers. Hence the process can take longer than usual. This could cause a lot of uncertainty and insecurity in the decision-making process.

4.2.8 Poor coordination and alignment

The coordination and alignment between different types of projects is not that strong at the moment, for instance between machine projects and component projects and between component projects and investment projects. There has been some type of reporting between them. According to informants, they deal mainly with component projects, but at a higher level it includes aftermarket, design, purchasing, electronics, software part projects and so on. The case company adopted two different stage-gate models: one is for 1-5 type of projects and other is for 6-7 (see the figure 2). The coordination and alignment have recently been improved by visually connecting each phase or stage into two different models. However, in reality, the coordination and alignment is more dependent on the people involved in those projects. For example, as shown in Figure 2, one new component introduction project might end up in multiple investment projects. Hence, it is essential to know the connection between these

projects to better manage new product introduction, especially what is important and what needs to be ready from investment and assembly projects to make sure that the new component introduction project passes through the gate. Further, most of the projects involved the engineering or purchasing personnel from other sites that usually participated virtually through Skype. The team effort and cross-functional work is still not efficient in the case company.

4.2.9 More projects with less competences

Project management competence is other challenge. In the case company, more projects are initiated in the technology, and consequently there are more NPI projects, including several investment projects. Sometimes small projects are initiated for the convenience of having a project manager. With the recent reorganisation, most of the mangers are new in the role and on most occasions new personnel take the role of project manager. Then, there are more projects that followed gate model, which are more administrative and not a resource efficient. Different organisations in the production needed training explaining in detail what is expected from the project in terms of resources and deliverables.

5 CONCLUDING REMARKS

Results of this explorative case study provide support for the management of NPI projects. Despite actively addressing project management challenges in NPD projects, prior literature has so far not focused on challenges in managing NPI projects. This paper closes this knowledge gap by deepening our understanding on the issues associated in the project management in NPI process, which is critical given the large potential for cost savings. The findings are particularly relevant considering a growing managerial and theoretical interest in better understanding the project management in dealing with complex operational processes. The findings are relevant to the NPD and operations management academics, plant managers, industrialization project managers, product and production development managers, and production engineering managers. Some of the findings confirmed the previous research related to the project management in NPD projects especially challenges associated to the resources, gate reviews, coordination and alignment, and communication. It further proposed additional challenges in the context of NPI projects. Though the findings were drawn from a case study in the heavy-duty vehicle industry, the author believes that results could be applicable to the largest manufacturing companies and project-based production companies outside the industry. Future research will focus on understanding the project management challenges specific to seven types of new product introduction projects. Results are based on a case study in a single company, which must be validated with more empirical observations in separate set of companies.

REFERENCES

Adler, P. S. (1995), "Interdepartmental interdependence and coordination: The case of the design/manufacturing interface", *Organisation Science*, Vol. 6, pp. 147- 167.

Almgren, H. (1999), *Pilot Production and Manufacturing Start-up in the Automotive Industry: Principles for Improved Performance.* Doctoral Thesis, Chalmers University of Technology.

Akinc, U. and Meredith, J. (2015), "Make to Forecast: Customization with Fast Delivery", *International Journal of Operations and Production Management*, Vol. 35, No. 5, pp. 728-750.

Browning, T.R. and Heath, R.D. (2009), "Reconceptualizing the Effects of Lean on Production Costs with Evidence from the F-22 Program", *Journal of Operations Management*, Vol. 27, No. 1, pp. 23-44.

Bellgran, M. and Säfsten, K. (2010), *Production Development: Design and Operation of Production Systems*, Springer London.

Berg, M., Fjällström, S., Stahre, J. and Säfsten, K. (2005), "Production rampup in the manufacturing industry: Findings from a case study", *3rd International Conference on Reconfigurable Manufacturing*, Ann Arbor.

Bruch, J. and Bellgran, M. (2013), "Characteristics affecting management of design information in the production system design process", *Int. Journal of Production Research*, Vol. 51, No.11, pp. 3241-3251.

Bruch, J. and Bellgran, M. (2014), "Integrated portfolio planning of products and production systems", *Journal of Manufacturing Technology Management*, Vol. 25, No. 2, pp.155-174.

Berglund, M., Harlin, U. and Gullander, P. (2012), "Challenges in a product introduction in a cross-cultural work system – a case study involving a Swedish and a Chinese company", *Swedish Production Symposium*, 6-8 November, Linköping, Sweden.

Carrillo, J. E. and Franza, R. M. (2006), "Investing in product development and production capabilities: The crucial linkage between time-to-market and ramp-up time", *Eur. J of Operational Research*, 171, 536-556.

Cooper, R. G. (2009), "How companies are reinventing their idea-to-launch methodologies", *Research-Technology Management*, Vol. 52, No. 2, pp. 47-57.
Chirumalla, K., Schedin, J. and Jackson, M. (2016), "Development projects, stage-gate models, and degree of newness: Examining the correlation from a production perspective", 23rd EurOMA Conference, Norway.
Dekkers, R., Chang, C. M. and Kreutzfeldt, J. (2013), "The interface between "product design and engineering and manufacturing: A review of the literature and empirical evidence", *International Journal of Production Economics*, Vol. 144, No. 1, pp. 316-333.
Dooley, L., Lupton, G. and O'Sullivan, D. (2005), "Multiple project management: a modern competitive necessity", *Journal of Manufacturing Technology Management*, Vol. 16, No. 5, pp. 466-482.
Dröge, C., Jayaram, J. and Vickery, S.K. (2000), "The ability to minimise the timing of new product development and introduction: An examination of antecedent factors in the North American automobile supplier industry", *Journal of Product Innovation Management*, Vol. 17, No.1, pp. 24-40.
Fjällström, S., Säfsten, K., Harlin, U. and Stahre, J. (2009), "Information enabling production ramp-up", *Journal of Manufacturing Technology Management*, Vol. 20, pp.178-196
IJOPM special issue, (2015). *Old theories, new contexts: Extending operations management theories to projects*.
Javadi, S., Bruch, J, Bellgran, M. and Hallemark, P. (2013), "Challenges in the industrialization process of low-volume production systems", *11th Int. Conference on Manufacturing Research*, Cranfield University, UK.
Johansen, K. (2005), *Collaborative Product Introduction within Extended Enterprises*. Doctoral Thesis.
Jepsen, A.L. and Eskerod, P. (2009), "Stakeholder analysis in projects: Challenges in using current guidelines in the real world", *International Journal of Project Management*, Vol. 27, pp. 335-343.
Ruffles, P. C. (2000), "Improving the new product introduction process in manufacturing companies", *International Journal of Manufacturing Technology and Management*, Vol.1, pp.1-19.
Kach, A., Azadegan, A. and Dooley, K. J. (2012), "Analyzing the successful development of a high-novelty innovation project under a time-pressured schedule", *R&D Management*, Vol. 42, No. 5, pp. 377-400.
Lakemond, N., Johansson, G., Magnusson, T. and Säfsten, K. (2007), "Interfaces between technology development, product development and production: critical factors and a conceptual model", *International Journal of Technology Intelligence and Planning*, Vol. 3, pp. 317-330
Munthe, C. I., Uppvall, L., Engwall, M. and Dahlen, L. (2014), "Dealing with the devil of deviation: managing uncertainty during product development execution", R&D Management, 44, 2, 203-206.
Nihtila, J. (1999), "R&D-Production integration in the early phases of new product development projects", *Journal of Engineering and Technology Management*, Vol. 16, No.1, pp. 55-81.
Harland, P. E. and Uddin, Z. (2014), "Effects of product platform development: fostering lean product development and production", *International Journal of Product Development*, Vol. 19, 5/6, pp. 259-285.
Surbier, L., Alpan, G. and Blanco, E. (2013), "A comparative study on production ramp-up: state-of-the-art and new challenges", *Production Planning & Control*, pp. 1-23.
Sommer, A.F., Popovska, I.D. and Jensen, K.S. (2014), "Barriers towards integrated product development—Challenges from a holistic project management perspective", *Int. J. Project Management*, 32, 970-982.
Sambasivarao, K.V and Deshmukh, S.G. (1995), "Selection and implementation of advanced manufacturing technologies", *International journal of Operations & Production Management*, Vol. 15, No.10, pp.43-62.
Slamanig, M. and Winkler, H. (2012), "Management of product change projects: a supply chain perspective", *Int. J. Services and Operations Management*, Vol. 11, No.4, pp. 481-500.
Säfsten, K. and Aresu, E. (2002), "Assembly system design and evaluation of 15 manufacturing companies in Sweden", *Manufacturing Systems*, Vol. 31, No.1.
Säfsten, K., Fjällström, S. and Berg, M. (2006), "Production ramp-up in the manufacturing industry experiences from a project under extreme time pressure", 39th CIRP ISMS, 7-9 June 2006, Ljubljana, Slovenia.
Tatikonda, M. V. and Rosenthal, S. R. (2000), "Technology novelty, project complexity, and product development project execution success: a deeper look at task uncertainty in product innovation", *IEEE Transactions on Engineering Management*, Vol. 47, No. 1, pp. 74-87.
Terwiesch, C. and Bohn, R. (2001), "Learning and process improvement during production ramp-up", *International journal of production economics*, Vol. 70, No.1, pp. 1-19.
Yin, R. K. (2009), *Case study research: Design and methods*, Sage Publications, Incorporated.
Wheelwright, S. C. and Clark, K. B. (1992), "Creating project plans to focus product development", *Harvard Business Review*, Vol. 7. No. 2, pp. 70-82.

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