

Inter-organisational coordination in Ramp-up execution - a multiple case study

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Abstract

While fast product development with early prototyping and reduction of both cycle time and lead time are major concerns, there is little research on ramp up management. This paper examines the structural complexity of the ramp-up processes including the interactions with suppliers and analyses the degree of fragmentation in the process planning and execution. Resource dependence theory (RDT) is used as central explanatory framework for inter-organisational interdependencies formation throughout the planning and execution of the ramp-up activities and milestones. This study aims at exploring inter-firm resource dependence connections in production initiation and its influence upon the effectiveness of manufacturing ramp-up.

Keywords: Ramp-up management, Resource Dependence Theory, Case Study

Introduction

Inter-organisational issues are of high importance in operations management with its focus on the flow from suppliers through the production system and to customers. Development of operations system will involve demands from external parties such as suppliers and customers as well as internal such as product development, procurement and distribution. The need for inter-organisational coordination is thereby high. While there is considerable research on inter-organisational issues, there is less on the processes. One such process is the phase of going from product development to full scale production. There are issues on both manufacturability and assemblability but little on the scale up. This research is focussing on that particular part of the process, the ramp-up process management.

Despite the growing body of research, empirical investigation into the ramp-up topic from the management perspective falls short and there are therefore still many opportunities investigating this area from different theoretical lenses. Some advances within ramp-up management studies are indeed made and a growing number of scholars are engaged in empirical and conceptual studies, see for instance (Brauner et al., 2016; Christensen and Rymaszewska, 2016; Heine et al., 2016; Lefakis, 2016). In the previous years some scholars have investigated this area although briefly, most notably Terwiesch with some contributions made in the early 2000 (Terwiesch and E. Bohn, 2001; Terwiesch and Xu, 2004; Terwiesch et al., 2001) addressing ramp-up production

before changing research focus to healthcare and innovation management. Other noticeable contributions can also be found in (Gopal et al., 2013; Gross, 2014), and while a recent study (Javadi et al., 2016) calls for investigating the role of external variables during the product introduction process, it only provides a structural explanation on characteristics of the ramp-up process, rather than focusing on the links between the internal organisational dynamics and the connections to the environmental constraints and dependencies of the ramp-up organisation. Twenty years ago, Tushman & O'Reilly came up with the organisational pre-condition for a long-term survival of the organisation which is in line with "The ability to simultaneously pursue both incremental and discontinuous innovation...from hosting multiple contradictory structures, processes, and cultures within the same firm" (Tushman and O'Reilly, 1996, p. 24). Since then both incremental and radical innovations have been extensively studied; however we know little about the organisational conditions for managing relationships, power imbalance, dependencies within and outside of the central organisational unit responsible for initiating production and ramping production to full volume, regardless of radical or incremental innovations.

Theoretical background

Some topics that have previously been brought up in the ramp-up management literature with knowledge management (Fjällström et al., 2009) as a dominant theory, deal with how actors adapt their preference within the organisation as they perform their tasks. The knowledge management is focused on creating experiences aiming at retaining and transferring expertise within the organisation, by forging relations that facilitate the knowledge sharing behaviour among different actors. Resource Dependence Theory (RDT) is well linked to knowledge management theory, in the sense that both are focused on the technological core of the organisation, which can be bridged to gain independence and control within a network. However while organisational learning is focused inward in the organisation, RDT is focused outward towards the environment, therefore the significance of these two lenses lays in the systematic ways of thinking and analysing the ramp-up organisation and its challenges within and outside its own environment.

The optimal ramp-up performance is seen in the light of efficiency and eliminations of problems leading to delays in full volume-production launch. The faster launch of product to market motivates the organisation to harness the benefits found in the first-mover-effects among others. However the optimal performance is always dependent upon external situations of the ramp-up business unit; this view is embedded within an open systems perspective and the argument here is that there's no single way in organising or making decisions throughout this process (Katz and Kahn, 1966). Through this theoretical lens this paper focuses on the extended form of relations exchange, where the ramp-up business unit gets together with other parts of the organisation and external machine- and raw material suppliers and tries to absorb these dependence relations, thus combining power within the organisation with a theory of how to manage its environment (Davis and Cobb, 2009). By contrast others argue that while organisations may be *motivated*, they may not always be *capable* of taking actions in managing external dependencies (Casciaro and Piskorski, 2004). While RD is regularly referred to as a theory in its own right (Hillman, 2009) it is in fact perceived as an overarching perspective, which integrates a theory of the environment and a theory of power to make forecasting about a variety of organisational responses (Aldrich, 2013).

An explanation of the construct of interdependence is significant, because it consists of two constructs: power imbalance (PI) and mutual dependence (MD) and they both

differ in types of impact on constraint absorption model, both in an independent and in an interactive way. PI captures the difference in the power of each actor over the other, and MD captures the existence of mutual dependencies regardless of whether the two actors' dependencies are balanced or imbalanced. (Casciaro and Piskorski, 2005, p. 170). Previous empirical studies have looked at the combined impact of the two constructs, though not tested them separately.

Casciaro and Piskorski (2005) proved that both PI and MD constructs can have contradictory effects on the organisation's ability to reduce dependencies. Another study of US automotive manufacturers and their suppliers conclude that the mutual dependence proves to have positive effects, in the sense that it enhanced the performance of procurement relationships for manufacturers; this is obviously in contrast with the logic of value appropriation, in which the stronger actors get a bigger share of the pie at the expense of the weaker ones. The study result shows that while manufacturer's dependence advantage weakens, its performance and supplier's power advantage has no significant effect on the performance (Gulati and Sytch, 2007).

Research issue and aim

This paper highlights the potential of RDT as a powerful explanation of inter-organisation relationships by providing an accurate portrayal of these dynamics and their symmetries as seen in the ramp-up business unit environment.

Research approach and design

The qualitative multiple case study unfolds the ramp-up business unit dependencies in its real world settings (Flynn et al., 1990; Meredith, 1998). This research design is adopted with the involvement of a medical device multinational manufacturing company to address the research objectives. To ensure strong research findings, multiple case-based approaches with ethno-methodological study are applied to pursue the in-depth contextual analysis and cross case analysis. Multiple sources of evidence combining qualitative data, observations, interviews and internal company documentation such as contractual agreements with suppliers are selected for exploring the complexities of the sub-processes (see appendix for further details). The combination of these approaches is actively sought for because it provides improved possibilities for triangulation. For the sampling, the selection of multiple cases have increased external validity and helped resist observer bias. The use of multiple cases creates more robust and testable theory for theory building purpose (Eisenhardt and Graebner, 2007; Eisenhardt, 1989). All 6 projects are selected for multiple reasons, they differ significantly in their operations practices; ranging both from the successful to the less successful projects, within the same manufacturing site and they operate under high variability environments. The six cases consist of both radical and incremental technologies and process and we have found that these dissimilar contexts enrich and provide an exhaustive view of the studied relationships.

The unit of analysis is in strong contrast with the majority of ramp-up management studies because it shifts from the prevailing production introduction process to a new unit of analysis – namely the inter-organisational relationship of dependence that is found in the ramp-up organisation. The concern here is the focal ramp-up business unit and its multiple resource dependencies with other departments and organisations in its environment. The conducted interviews were exploratory and open-ended with the intention of clarifying the nature of the ramp-up business unit's relationships with the involved departments as well as clarifying the dynamics of interaction between operations management organisation and the external material and machine suppliers.

The product and process developments are organised according to the Stage-Gate-Model, and as such gate evaluation reports were analysed in-depth and we have unveiled the power imbalance and mutual dependence across departmental collaboration as well as material supplier evaluation, selection, involvement and elimination.

The studied resources are not only the physical materials, but also the technological, like knowledge and expertise. The value of these resources has also been studied, as well as mechanisms such as life cycles, process and design changes, operations progress and development during these projects are also studied; these phenomena and the relatively short time span of ramp up events are only evident through a multi-case research design.

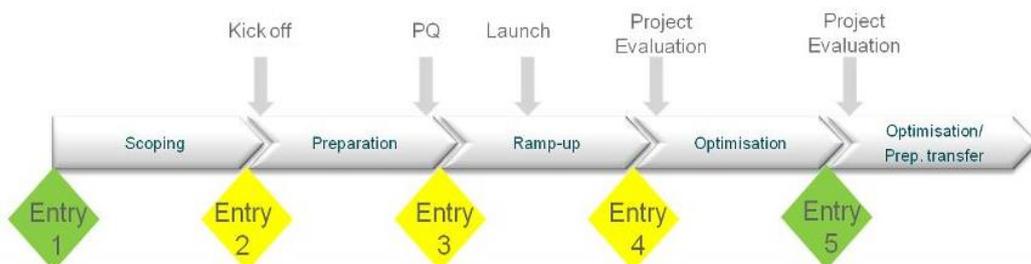
Findings

In the data “a comparison of a pattern of observed outcomes with some pattern of expected values derived from a given theory” (Bitektine, 2008, p. 162) was used. The selected cases address the alignment of complex ramp-up manufacturing process changes with the inter-firm resource governance formation and central ramp-up manufacturing performance in the context of resource dependencies.

The six cases are coded in relations to the novelty of both the product and the process technologies within the ramp-up management department. Forming a dyad - three cases are classified as radical and three as incremental. Furthermore cross-departmental involvement –classified as cross functional integration with the ramp-up business unit is coded in two polar values identified as high and low involvement. Finally, the dimensions of physical resources which would make it critical and therefore link them to the product output were focused. Hence, the third dependence that was identified is the material and machine suppliers, whom are coded according to their strategies with the studied organisation. A total of 128 material and machine suppliers are evaluated, and the two polar values here are the supplier’s pricing structures, i.e. whether they were in scope with existing products and the suppliers’ co-development commitment and willingness to offer exclusivity.

Through a close examination of all 6 cases, RDT is used in identifying and comparing the number of resources, activities and collaborative agreements. The results demonstrate that not all types of inter-organisational measures are equally fitting for coping with resource dependencies during the initiation of production considering the novelty of the product/process. Common for all 6 cases studied are the overall project tasks organised as stages. The project stages are as seen in figure 1 scoping, preparation, ramp-up and finally optimization and preparation for machine transfer to volume sites in foreign countries.

Figure1 Ramp-up process



All these stages are performed and evaluated with the direct but fluctuating degree of involvement of project management including close collaboration with suppliers, logistics management, procurement, quality management, validation management, employee health and safety management, technical, sterilization and microbiological experts. Furthermore we found that the formation of inter-organisational relationships and interdependencies occur during the pre- ramp-up project planning and continues throughout each milestone entry point, and after the project performance evaluations. The organisation and the governance of the studied projects make these dependence formations reactionary, rather than planned and standardized by the involved actors.

The inter-organisational relationships are described by power imbalance and mutual dependencies towards other functions in the rest of the organisation. Furthermore these relationships are contingent with the degree of changes made to the product/process while in the ramp-up stages. It was discovered that radical changes made to the product or the process increases the ramp-up business unit's dependency on the material suppliers' resources and expertise of new technologies, material, and process as well as high involvement from other functions in the company. However with small incremental changes, the supplier's price increase strategy is less likely to lead to power imbalance and external control over the organisation. Based on the findings the following theoretical propositions are proposed:

1. The effects of PI and MD between the ramp-up business unit and the material suppliers are bounded by the degree of novelty of the innovation changes.
2. The more radical changes made to the product/process, the higher degree of ramp-up department dependence on cross functional involvement.
3. PI effects between ramp-up business unit and other functions are moderated by the degree of involvement.
4. PI effects between the ramp-up business unit and its suppliers are moderated by the strategic choices made by the supplier.

The focus is on the dependencies dictated by the structure of the relationships which will now be analysed and discussed.

Analysis

The data that will now be analysed have been collected, transcribed and coded from key informants because the aim is to explore the contingencies found in the mutual dependence and the power imbalance among the actors. In accordance with (Casciaro and Piskorski, 2005) who suggest employing the difference between each party's dependence on the other as power imbalance in a dyad, and the sum of each party's dependence as mutual dependence. This suggestion is explored by assigning the value (1) to incremental changes in the product/process's dependency on cross functional involvement, and the value (2) to radical or novel changes and its -higher- dependency on the material supplier's strategic stance. (See Figure 2).

For instance, '*confgr 1 or 1b*' represent the PI between the radical and the low involvement of cross-functional units or the high cost strategy chosen by the supplier, valued at 1, which is the difference between their dependencies on each other ($2 - 1 = 1$). Their MD is on the other hand the sum of their joint dependencies ($2 + 1 = 3$).

The power imbalance and mutual dependence are considered simultaneously with the purpose of producing a theoretically sound representation of the power-dependence structure as seen in table 1; this is done because the goal here is to address the 4 propositions and identify potential exploitation risks embedded in these relationships. A

note as taken on each party's dependence profile as power imbalance in figure 1, configuration of PI and MD.

For instance 'configr 1' the PI value is 1, which is the difference between the dependencies of the functional integration level and its dependence on innovation being a radical. In 'configr 2' the power is symmetric because both the radical changed found in the ramp-up business unit and the high functional integration are equally highly dependent on one another. Similarly, this symmetrical power effect is also present in 'Configr 2b' because the supplier's favourable strategy and the radical changes made to the product or the process in the ramp-up business unit are highly dependent on one another. In 'Configr 3 and 3b' both have equally low dependency on one another.

Product and Process changes in the Ramp-up business unit			<i>Functional integration</i>		<i>Material supplier strategy</i>	
			<i>Low</i>	<i>High</i>	<i>High cost/ constant price increase</i>	<i>Competitive prices/ co- development</i>
	<i>Dependence on the other</i>		<i>1</i>	<i>2</i>	<i>1</i>	<i>2</i>
<i>Incremental</i>	<i>1</i>	<i>Configr:3 PI: 0 MD: 2</i>	<i>Configr:4 PI: 1 MD: 3</i>	<i>Config:3b PI: 0 MD: 2</i>	<i>Configr:4b PI: 1 MD: 3</i>	
<i>Radical</i>	<i>2</i>	<i>Configr:1 PI: 1 MD: 3</i>	<i>Configr:2 PI: 0 MD: 4</i>	<i>Config:1b PI: 1 MD: 3</i>	<i>Configr:2b PI: 0 MD: 4</i>	

Figure 2 – Degree of changes, functional integration, and strategy effects on Power Imbalance (PI) and Mutual Dependence (MD)

<i>Configu- ration</i>	<i>Degree of changes</i>	<i>Functional integration</i>	<i>Strategy</i>	<i>Power imbalance</i>	<i>Mutual depen- dence</i>	<i>Exploi- tation risk</i>
<i>1 & 1b</i>	<i>Radical</i>	<i>Low</i>	<i>High cost</i>	<i>Asymmetrical</i>	<i>Moderate</i>	<i>High</i>
<i>2 & 2b</i>	<i>Radical</i>	<i>High</i>	<i>Co-develop</i>	<i>Symmetrical</i>	<i>High</i>	<i>Low</i>
<i>3 & 3b</i>	<i>Incremental</i>	<i>Low</i>	<i>High Cost</i>	<i>Symmetrical</i>	<i>Low</i>	<i>Low</i>
<i>4 & 4b</i>	<i>Incremental</i>	<i>High</i>	<i>Co-develop</i>	<i>Asymmetrical</i>	<i>Moderate</i>	<i>High</i>

Table 1 – Control effects of product/process changes, functional involvement and supplier strategy on the effects of power imbalance and mutual dependence on exploitation (Adapted from Casciaro and Piskorski, 2005; Özen et al., 2016).

Discussion and Conclusion

This paper proposes a shift in the ramp-up management unit of analysis by employing resource dependence theory as the central lens. From that a strong explanation of inter-organisations relationships is provided. The motivation for this study is to offer an explicit theoretical realisation of power as an inherently dyadic phenomenon which allows the managers to capture both organisations' motivation to predict, plan and stabilize the procurement of resources and their ability to do so.

Furthermore the results of this study show the degree of changes in the product design or the process and the strategy of the material supplier moderate the impact of mutual dependence and power imbalance. As the changes to the product or the process

become more radical the ramp-up business unit's dependence on their suppliers increases which in turn, strengthen its efforts to construct relations with suppliers, through co-development strategies for instance. By contrast, the smaller incremental changes induced, the more reduced the ramp-up unit's dependence is on the suppliers and on functions from other departments.

This study found different combination between the degrees of changes made to the product or the process at the ramp-up stage combined with fragmented supplier strategies result in several configurations of power imbalance and mutual dependence. The paper presented dyads with PI is asymmetrical with high level of exploitation because of the unequal power and high or moderate level of mutual dependence.

The study drew a theoretical distinction between power imbalance and interdependence; RDT addresses this by posing the general question of how and why the more powerful organisation would enter balancing processes with a dependent organisation, and thus give up the organisation's power and the advantageous exchange conditions it harness (Casciaro and Piskorski, 2005).

Contribution and relevance

The effective manufacturing ramp-up processes, expressed in terms of time-to-volume, time-to-market and time-to-quality, are essential, yet often overlooked element of a successful product introduction. The relevance of this study is justified by its innovative approach in looking at inter-firm collaboration during this stage of product development and production since it has this far not been researched. The added value of this research comes from considering the wider inter-organisational influence and the significance of the changes throughout the ramp-up process. When managed through actions in response to the demands placed upon them, this leads to faster introductions of quality products creating competitive advantage. It can be achieved by managing the power/dependence effects on the product and process changes, which is in direct response to the recent call for study (Javadi et al., 2016).

This paper examines the complexity of the ramp-up processes dependencies including the interactions with suppliers and analyses the degree of fragmentation in the process planning and execution. Resource dependence theory is used as a central explanatory framework for the formation of inter-organisational interdependencies throughout the planning and execution of the ramp-up activities and milestones (Pfeffer and Salancik, 1978). The study fulfilled its aim by discovering and exploring the connections between the inter-firm resource dependence on production initiation and specifically its influence upon the effectiveness of manufacturing ramp-up, what symmetries have been identified, and where could potential exploitation or opportunistic risk be found.

Further work can be done with the aim of examining how knowledge and relationship factors grow and interact in joint innovation projects between organisations. The findings of the research presented in this paper relate to both theory development and managerial implications.

Contribution to the literature and improvement suggestions

For the first time resource dependence theory is applied to the phenomenon of production launch and problem solving. Albeit neither manufacturing ramp-up nor the RDT framework are particularly new research topics, the scientific evidence on the process is rather scarce. Empirical evidence on ramp up management is largely focused on automotive and hardware industries (Liker and Wu, 2000; Surbier et al., 2014; Terwiesch et al., 2001) The current state of literature with its gaps, as well as the

identified challenges of manufacturing ramp-up in the studied cases, serves as a justification for this research.

This paper addresses the challenges of the manufacturing ramp-up's inter-organisational dependencies and focuses on the empirical analysis thereof, in the context of level of cross functional involvement as well as material and machine suppliers' strategy. The research has been carried out by studying organisational mitigation during the execution of 6 ramp-up projects.

Managerial strategies for dealing with dependence

From this study we have learned that RDT is concerned with standard operative procedures that manage the organisation's resource dependence in the environment; which makes the RDT about organisational process models. We have also learned that managers create and select procedures that mitigate relations in the environment and seek relations that create favourable exchanges.

To manage the environmental fluctuations, the following five strategies are proposed. In general, managers could avoid or reduce the dependencies and the organisation can do so by:

1. **Stockpiling strategy:** this is concerned with controlling the inputs and the outputs released to the volume manufacturing sites, which can be seen as a passive response. The challenge is that ramp-up production significantly dependent on raw materials suppliers, but that material isn't always available and some are delivered out of the specs.
2. **Leveling strategy:** it is concerned with controlling the input-output ratio which can be seen as an active involvement by reaching out into the environment and providing the suppliers with inputs about ramp-up production capacity requirements.
3. **Forecasting strategy:** If environmental fluctuations can't be managed by stockpiling or levelling, the ramp-up function might have to adapt by anticipating or forecasting volume production launch or market launch and how the changes made to the product or process don't result in further delays.
4. **Scale adjustments strategy:** This doesn't jeopardize the core of the ramp-up production site, but rather it manages its size.
5. **Shaping dependence relations strategy:** This choice can be achieved through bridging actions, which can be done through negotiations with other organisations, exchanging resources with them, pooling resources across them, or by performing mergers and absorbing another firm in its entirety.

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Appendix 1

Data Sources between March 2013 and December 2015

<i>Source</i>	<i>Number</i>
<i>Interviewees</i>	
• <i>CEO</i>	2
• <i>Executive VP, Global Operations</i>	5
• <i>VP Pilot, Ramp-up & Machine Transfer</i> <i>Every 4-5 weeks</i>	28
• <i>Project managers</i>	22
• <i>PD managers</i>	6
• <i>SC Managers</i>	3
• <i>Machine and raw material Suppliers</i>	1
 <i>Archival records</i>	
• <i>Strategy presentations & white papers</i>	5
• <i>Contractual agreements with suppliers</i>	8
• <i>Meeting minutes</i>	45
 <i>Observations</i>	
• <i>Strategy meetings</i> → <i>Quarterly</i>	8
• <i>Board of directors meetings</i> → <i>Every 4-6 weeks</i>	25
• <i>Core group meetings</i> → <i>Weekly</i>	30
• <i>Observations in office (4-6 hours/day)</i> → <i>Sporadic</i>	141
• <i>Social events</i> → <i>Annually</i>	5

The total number of interviewees was 67; Archival records totalled 58, and observations 209