Opening up intrafirm R&D: Insights from the organisation of product and process innovation

Markus Bergfors¹ markus.bergfors@ltu.se
Andreas Larsson¹ andreas.larsson@ies.luth.se
¹Centre for Management of Innovation and Technology in Process Industry, Luleå University of Technology, 971 87 Luleå, Sweden

Effective and efficient organisation of research and development is critical for firm performance. In this regard the centralisation versus decentralisation of R&D is a key issue that has been debated heavily. The resource-based view argues that R&D activities that are of strategic importance, have a wide applicability within the firms, or are potentially disruptive should be under tighter corporate control. However, while previous research has predominantly focused on product innovation, often equating R&D with the development of new products, this study examines the centralisation-decentralisation issue from a product, as well as a process innovation perspective. In this regard, case studies of three multinational companies, representing food and beverage, mining and minerals, and pulp and paper industry sectors advances the understanding of organising intrafirm R&D. The study reveals dual structures within the R&D organisation; one for product innovation and one for process innovation. A matrix consisting of product-process innovation on one axis and centralisation-decentralisation on the other is presented to illustrate nine forms in which the intrafirm R&D organisation can be configured. Depending on the objective of product and process innovation the R&D organisation should be either centralised or decentralised. Thus, by examining intrafirm centralisation-decentralisation in R&D organisations through a product and process innovation perspective this study opens up the R&D organisation and provide guidelines for organising intrafirm R&D.

1 Introduction

For a large number of firms, survival and growth is dependant on their ability to be innovative in developing new products, improving production processes, and quality in order to satisfy customers. These activities are often referred to as research and development (R&D) and carried out in specific organisations within firms. As R&D is such a critical activity firms constantly need to find ways of improving themselves in this area. Unfortunately, as R&D organisations are complex (Pisano, 1997) and difficult to manage (Sapienza, 1995; Schneiderman, 1991) it is often difficult to find good advice to pass on to practitioners on how to best organise R&D.

In organisational design there are two conflicting goals. On one hand, an organisation has to be strategically responsive in order to make necessary changes, while at the same time it needs to focus on carrying out its activities in the most efficient manner (Ansoff and Brandenburg, 1971; Duncan, 1976). In light of this conflict the question of centralisation versus decentralisation of R&D is a key issue for both managers and researchers interested in organisations. It has a long history of research in organisation theory (Ford and Slocum, 1977) and innovation management (Chiesa, 2001; Damanpour and Gopalakrishnan, 1998), as well
as being one of the hottest topics in research into multinational companies (Gupta and Govindarajan, 2000; Papanastassiou and Pearce, 2005; von Zedtwitz et al., 2004).

By focusing on the question of centralisation versus decentralisation of R&D this study seeks to advance the knowledge on organising innovation within firms. However, much of the prior research in this area has failed to recognise the significance of the type of innovation that the firm pursues. While the distinction between administrative and technical innovation has been dealt with (Daft, 1978) not much research has explored the differences between product innovation and process innovation. This lack of distinction between product and process innovation have often created confusion both in operational performance of industrial R&D and in academic research (Lager, 2002b) and managers and researchers have historically focused mainly on product innovation (Pisano and Wheelwright, 1995).

Three case studies in the process industry were selected to examine centralisation versus decentralisation of intrafirm R&D in relation to product and process innovation. The resource based view provides some theoretical concepts that explain when centralisation or decentralisation of R&D activities is appropriate. R&D activities that are of greater strategic importance, have a wide applicability within the firms, or are potentially disruptive should be under tighter corporate control, while activities that are less important for future resource development, a narrow range of application, and more focused on incremental innovation should be decentralised.

Evidence from the case studies showed that depending on the aims of product and process innovation there is a multitude of combinations that intrafirm R&D can take in regards to centralisation and decentralisation. In that sense the conventional notion of R&D organisational design, equating R&D more or less with product innovation, does not present a complete picture. This opening up of the intrafirm R&D organisation can further our understanding of innovation and R&D organisations and help managers in making better choices in regard to managing and organising. The findings from the case studies lay the foundation for a matrix that illustrates the different forms intrafirm R&D may take. This matrix can be used by both managers and researchers to better understand the organisation of R&D activities and thus opening up the intrafirm R&D.

2 Centralisation, decentralisation, and innovation

2.1 Defining centralisation and decentralisation

Centralisation has been defined in a variety of ways although most refer to the distribution of power and the degree to which decision making and authority is concentrated a single point within the organisation (Duncan, 1976; Hall, 2002; Pugh et al., 1963). When most decisions are made hierarchically, that organisation is often said to be centralised, while in a decentralised organisation most decisions are delegated to subordinate personnel. However, there are at least three common uses of centralisation concepts; vertical (the dispersion of power down the chain of authority), horizontal (the extent to which non-managers control decision processes), and physical (concerning the location of facilities, people and objects) (Mintzberg, 1999). Because the terms are used in so many different ways centralisation and decentralisation “represent the probably most confused topic in management” (p95) (Mintzberg, 1999).

This study uses the concept of vertical centralisation to distinguish between centralised and decentralised R&D. R&D activities being controlled from higher up in the hierarchy are considered being centralised, while activities controlled lower down are considered
decentralised. Although the centralisation and decentralisation are not absolute term, but rather two ends on a continuum (Corporate and divisional R&D can take several forms along this continuum as illustrated by Chiesa (2001) and Argyres and Silverman (2005)) they will be treated as such in this study. The aim is not make comparisons but to explore general differences in the organisation of product and process innovation.

2.2 Centralisation, decentralisation and the resource based view

The resource based view suggests that firms grow and remain competitive because they are able to exploit of their unique resources (Barney, 1991; Penrose, 1959; Wernerfelt, 1984) and capabilities (Leonard-Barton, 1992a; Teece et al., 1997). The critical task in the resource-based approach to strategy is to determine the most favourable composition of resources (Grant, 1991) and to continuously create new and develop existing capabilities (Leonard-Barton, 1992a). For many firms the R&D organisation has a central role in managing and developing resources.

When applying the logic of the resource based view to the question of centralisation versus decentralisation of R&D some aspects are immediately implied (shown in figure 1);

a) In light of the importance that R&D has on the creation and development of resources and capabilities, and in turn on competitiveness, it is clear that corporate level strategy must address these issues (Grant, 1991; Teece et al., 1997). This is supported by studies which find that senior management plays a huge role in building capabilities (Verona, 1999) and by Leonard-Barton who says that, as the emphasis on organisational learning over immediate output is critical for long term competition, R&D should be consciously managed for continuous organisational renewal (Leonard-Barton, 1992a). Simply put, the resource based view suggests that resources and activities that are more important for the firm should be under corporate control (figure 1).

b) Prahalad and Hamel argue that a corporation should be built around a core set of competencies by which a firm can get access to a wide variety of markets (Prahalad and Hamel, 1990). However, if these synergies are to be captured across businesses corporate R&D needs to play an active role (Chiesa, 2001; Markides and Williamson, 1996). This view is supported by Argyres and Silverman who in studying R&D organisational structure in relation to competencies and knowledge in more detail found that firms in which R&D is centralised tend to pursue R&D that has a greater and broader impact on future technological development (Argyres and Silverman, 2004). In conclusion, the resource based view suggests that activities that aim at wider application within the firm or achieving a broader set of knowledge or competencies should be centralised (figure 1).

c) The notion that resources are slow to change is central in the resource based view (Penrose, 1959) and there is a clear path dependence in the resources and capabilities that a firm can utilise. Given that, any disruptive technology has the potential of severely disturb profitability for any incumbents (Anderson and Tushman, 1990; Christensen, 1997) so being able to generate fundamentally different, or radical, innovations or guarding the company from discontinuities may be critical for firm survival. Studies of radical innovation has found that these were more likely to occur in centralised structures (Ettlie et al., 1984) and separated from ongoing business activities (Rice et al., 1998) while incremental innovation on the other hand benefit from being decentralised (figure 1). Guarding against technological discontinuities by scanning the environment is also facilitated by centralised R&D as these structures have the potential to scan more broadly (Argyres and Silverman, 2004; Leonard-Barton, 1995) and better monitor scientific development (Ahuja and Katila, 2004).
Factors influencing centralisation or decentralisation of R&D

- Resource creation and development
- Broadness of application pursued
- Radicalness of technology pursued

Centralised R&D
- R&D activities that are more important for creating or developing resources and capabilities
- R&D with a wide range of application across the firm
- R&D aiming at generating or guarding against disruptive technology

Decentralised R&D
- R&D activities that are less important for creating or developing resources and capabilities
- R&D with a narrow range of application within the division
- R&D aiming at generating incremental innovations

**Figure 1:** Model for centralisation or decentralisation of R&D according to the resource based view.

### 2.3 Importance of differentiating between product and process innovation

While the model proposed in **Figure 1** is generic, and thus explanatory for all types of innovation activities, there is a need to differentiate between product innovation and process innovation. The lack of distinction between product and process innovation have often created confusion both in operational performance of industrial R&D and in academic research (Lager, 2002b).

Previous research on structural differences pertaining to the type of innovation have concluded that an organisation can be structured to encourage one type or the other, but not both (Daft, 1978; Duncan, 1976; Ettlie et al., 1984). However, these studies have not taken into account that technical innovation consists of both product and process innovation. Historically, managers and researchers have either focused predominantly on product innovation and ignored process innovation (Pisano and Wheelwright, 1995) or simply equated the two (Clark and Fujimoto, 1991). As empirical research suggests that the types are related with different organisational structures (Cohen and Klepper, 1996; Lager and Hörte, 2005; Utterback and Abernathy, 1975) this study will separate these types:

a) **Product innovation** is defined as development driven by a desire to improve the properties and performance of finished products. Objectives of product innovation may be to develop new products, improve product properties, improve product quality etc. (Lager, 2002a).

b) **Process innovation** is defined as development driven by internal production objectives. Such objectives may be reduction of production costs, higher production yields, improvement of production volumes, environment-friendly production etc. (Lager, 2002a).
2.4 Research purpose

The aim of this study is to explore differences in organising R&D within firms in terms of product innovation and process innovation using centralisation or decentralisation of R&D activities as a measure of this differentiation. To achieve this aim, the model for centralisation or decentralisation of R&D proposed by the resource based view is used as a foundation for a framework based on the distinction of product and process innovation (Figure 2).

If there are structural differences in the intrafirm R&D organisation, this study will also be able to observe if these can be explained by the model based on the resource based view.

![Figure 2: Framework for studying centralisation and decentralisation as relating to product and process innovation.](image)

3 Method

3.1 Research method

In exploring centralisation versus decentralisation of product and process innovation a case based approach was used (Eisenhardt, 1989; Yin, 2003). The case study interviews were conducted with informants in top management positions in Sweden from April 2004 to March 2006 by a pair of researchers. The data from the interviews have been integrated with further case data collected via annual reports, internal reports and internal strategy documents.

3.2 Case selection and descriptions

Three cases were selected from the process industry; Arla Foods in the food and beverage sector, Billerud is in the pulp and paper sector, and Boliden in the mining and smelting industry. Innovation in the industry is primarily enabled by process innovation (Barnett and Clark, 1996) and while studies have show that while mature and low-tech firms have difficulties being innovative for organizational reasons (Dougherty and Hardy, 1996), their R&D organisations are often changing (Hirsch-Kreinsen, 2005). Understanding centralisation and decentralisation of product and process innovation in these firms and this industry can also provide generalisation of insights in a broader context. The case companies in this study were selected on several bases:
a) Though they may be defined as low-tech, they all rely heavily on their R&D organization to bring new products to market and improve manufacturing processes (Hirsch-Kreinsen et al., 2005).

b) The firms can be viewed as being typical of their respective industry sector (Eltringham, 1998; Phillips, 2000; Traill and Grunert, 1997). The R&D intensity of the selected firms is also equivalent to the respective industry averages (Lager, 2002a).

c) All firms are considered as multinationals as they all conduct R&D and have production plants in more than one country and sales offices in more than ten countries.

Arla Foods. Arla Foods is Europe’s largest dairy company with a turnover greater than 7 billion dollars and roughly 20,000 employees. Arla Foods is a co-operative owned by approx. 13,650 milk producers in Denmark and Sweden. With an R&D intensity of 0.5 – 0.6% Arla Foods has three R&D development centres and about 200 people working in R&D.

Billerud. Billerud is a packaging paper company with a sales turnover of 890 million dollars that employs 2,600 people in 11 countries. Production is concentrated to four paper mills in Sweden and the UK. The R&D intensity is about 0.7% and R&D is mainly conducted at each of the four paper mills. In total, around 50 employees work with product and process development.

Boliden. Boliden is a mining and smelting company focusing on production of copper, zinc, lead, gold and silver. The number of employees is approximately 4,500 and the turnover amounts to approximately 2.3 billion dollars annually. The Boliden plants are run as local subsidiaries, part of a greater portfolio, while the commercial organisation, mainly located in Stockholm, deals with purchasing, logistics and sales. Boliden, with an R&D intensity of 0.9% conducts most of its R&D at the mines and smelting plants.

4 Results from case studies

4.1 Arla Foods

At Arla Foods about 85% of the R&D budget is concerned with product innovation. However, the share of process innovation has been increasing as the cost focus in the dairy industry has become more prominent.

Product innovation

Arla Foods is divided into three autonomous divisions; Nordic, International and Ingredients were each division has a Research Centre. The R&D unit of the Nordic division conduct product innovation concentrated on fresh milk and desserts, the international division on cheese and butter and the ingredients division on milk powder. Each research centre is also responsible for knowledge creation within specific areas (such as knowledge around shelf-life, packaging, health etc.). A multitude of different end-products are then based on these broad knowledge areas as over 200 new products are launched each year. The knowledge creation takes place in product innovation as product development projects are used to spur and accumulate knowledge within these areas. The knowledge created in a research centre is spread to the other research centre through workshops and formal meetings. The R&D director at Arla Foods Nordic explained it as while “marketing focuses on how we can beat competitors here and now R&D is preoccupied with winning the war”.

Process innovation

Until recently, Arla Foods devoted limited attention to process innovation. Some projects were done locally but mostly Arla Foods relied on the suppliers of machinery to come up with
solutions to its process technology needs. However, the list of large suppliers to the diary industry is limited to three actors that have been unwilling to come up with process innovations which satisfy the need of Arla Foods. Therefore, Arla Foods has decided to establish a function which works exclusively with process innovation. The aim is to develop knowledge which can be spread to its 63 production plants world-wide. The intention is that new products can be extracted out of the existing production plant, through process innovation, and that costs of production can be reduced significantly. By pooling resources process innovation can become more efficient and better at “driving technological development” and managing large and “difficult projects”.

4.2 Billerud

At Billerud about 50% of the R&D budget is focused on product innovation and 50% is focused on process innovation. In general the focus at Billerud has shifted more towards products and product innovation while process innovation is more short-term issue than before.

Product innovation

Historically, new product development projects were initiated autonomous at each paper mill. However, while understanding customers has always been a focus at Billerud, product innovation initiatives were most commonly initiated by technicians and claims were made that the new products lacked market-orientation. Therefore, top management recently decided to organise product innovation activities into three “Business areas” (Market Pulp, Packaging Boards, and Packaging & Speciality Paper) with the intention of becoming better at understanding the customer and the industry value chain. As a matter of fact, “the main objective [of the new organisation] is to build this competence”. Product innovations are initiated through segment teams (such as sack paper, containerboard, and medical containers) which contained members of technical customer support, R&D and sales. The segment focus is centred on a number of products (such as MG, MF, and white liner) which in turn is based on broad product areas (such as Kraft paper or containerboard). The segment team, 5 or 6 employees, consists of appropriate experts’ regardless of production plant presence. Hence, the members of the segment teams are geographically dispersed and pooled for specific projects. Their activities are coordinated by four annual product innovation meetings where segment teams and a corporate innovation advisory board participate. The corporate innovation advisory board settle on a broad frame for resource allocation among future areas of product innovation and an overall strategy for product innovation is crafted on the basis of business segment attractiveness.

Process innovation

When it comes to process innovation the head of R&D at Billerud Karlsborg states “the objective… is to develop what we already have –and that we do best ourselves”. Process innovation is conducted, more or less in isolation, at each paper mill as it deals mostly with incremental activity carried out close to each production plant (i.e. improving efficiency of existing paper machines). Hence, each production plant is autonomous on process innovation as each plant is kept responsible for production yields and production volumes. There is no formalised cross-plant coordination and no formal routines for knowledge sharing on process innovation. Instead, issues concerning process innovation are handled through personal networks. An interesting comment from an employee in technical customer support was that ” when we talk about innovation at Billerud, we generally talk about innovation activities related to the development of new products… not activities related to innovation in the production process”.

4.3 Boliden

At Boliden more than 95% of R&D budget is considered being process innovation, with the remaining 5% being focused mainly on administrative and market innovation. This percentage has been relatively stable for some time.

**Product innovation**

Boliden does not conduct any product innovation. The smelters extract and produce predetermined basic metals (such as zinc, copper, gold and lead) out of ore. The challenge for Boliden is to produce the same commodity product with varying quality of input materials.

**Process innovation**

At Boliden each production plant is autonomous with respect to process innovation. The objective of R&D is to make everyday improvements in the continuous production process and therefore many of the R&D employees are attached to a certain part of the production line and decisions are made locally over a cup of coffee. The aim of process innovation in Boliden is according to head of R&D at the smelter in Rönnskär to “make incremental process innovations to the existing production process” and to do this Boliden has “chosen to work with proven technology”. The main drawback of decentralised process innovation as identified by Boliden is the lack of long term dedication and that “we don’t know what we are doing in 10 years”. Another drawback is “as most of the R&D employees are working very close to the production process we have to avoid ending up with yet another production engineer… the autonomous R&D employees should contribute with process improvements which are more significant and long-term than the ones that the production engineer deliver”.

5 Discussion of research findings

Process innovation often constitutes a large share of R&D spending. It is used to reduce production costs, obtain higher production yields, improve production volumes and product recoveries, make production more environment-friendly etc. Product innovation, in contrast, focuses on improvement of product properties and performance of finished products. In a sense, instead of taking out costs, it focuses on adding value to the end product. This has been the main focus of most previous studies on intrafirm R&D. In making a distinction between product innovation and process innovation in terms of centralisation and decentralisation the case studies found that there were very different rationales behind the selected organisational structures. The different structural choices are shown in figure 3.

At Arla Foods both product and process innovation is centralised. Product innovation is centralised primarily to build knowledge and competence in general areas. This competence is then applied when developing a multitude of different products based on these knowledge areas. Process innovation is primarily centralised in order to manage the development of more long-term and more radical process innovation projects.

At Billerud, were knowledge about customers is important, product innovation is centralised while process innovation is decentralised. Product innovation is concerned with building competence concerning customers and the industry value chains, and by pooling resources centrally Billerud can develop a wider range of products. Process innovation is mainly concerned with incremental innovations and optimising existing machines and processes.

At Boliden there is no product innovation, only decentralised process innovation. The reason for decentralisation is to make incremental improvements aimed at cutting costs in the
short term. As each plant is run independently there is little incentive to pursue innovations with a broader application.

![Diagram showing combinations of centralised and decentralised intrafirm R&D structures.](image)

**Figure 3:** Combinations of centralised and decentralised intrafirm R&D structures.

The results of the case studies open up for a multitude of possible intrafirm R&D organisational configurations concerning degree of centralisation. In fact, there are nine possible combinations of product and process innovation of intrafirm R&D (figure 3);

*Product innovation and process innovation*

1) Product development centralised and process innovation centralised.
2) Product innovation centralised and process innovation decentralised.
3) Product innovation decentralised and process innovation centralised.
4) Product innovation decentralised and process innovation decentralised.

*Product innovation or process innovation*

5) Only centralised product innovation
6) Only decentralised product innovation
7) Only centralised process innovation
8) Only decentralised process innovation

*No product innovation or process innovation*

9) No intrafirm R&D

The matrix can be used to consider what configuration is most suitable for the kind of innovation the firm pursues. It can also be used to predict what kind of innovations will be produced given the structure of the existing intrafirm R&D organisation. Understanding a firm’s position in the matrix will make simpler any benchmarking of R&D practices or organisational design issues other than centralisation versus decentralisation.
5.1 Further research

This paper only studies intrafirm R&D. However, a great deal of R&D activities in these industries in particular takes place outside of the intrafirm R&D organisation – either in networks or in external research institutes. It is commonly argued that outside sources of knowledge are often crucial to the innovation process. Therefore, interfirm collaboration (e.g. alliances, joint ventures) are considered vital to success in R&D. As this paper focuses on intrafirm organization of product innovation and intrafirm organization of process innovation no attention has been devoted to interfirm organization of these two. However, there is definitely a relationship between intrafirm R&D and interfirm R&D. It is argued that knowledge created through intrafirm R&D affect the ability for corporations to recognize the value of new information, assimilate it, and apply it to commercial ends (Cohen and Levinthal, 1990). The concept of absorptive capacity, argue that by having already developed some expertise in an area, a corporation knows more precisely what additional information it will require to be able to effectively exploit any new advances that may materialize (Cohen and Levinthal, 1994). The RBV argues that centralised R&D, in this case with respect to either process or product innovation, will generate knowledge, and innovations, which are relevant across the firm (wider range of application) and spawn more radical innovation than a decentralised R&D. Hence, centralized intrafirm R&D will facilitate more distant (capability-broadening) search for sources of outside knowledge while decentralized R&D will encourage more immediate (capabilities-deepening) search (for a more thorough discussion, see Argyris and Silverman, 2005). Additional research is needed to explore the relationship among intrafirm product and process innovation and interfirm R&D.

This study, while focusing on intrafirm R&D, has not drawn any clear boundaries for the R&D organisation. For example, where would the “learning laboratory” (where all innovation is organised within the production unit) proposed by Leonard-Barton (Leonard-Barton, 1992b) fit in this model. Is it centralised, decentralised, or in no department whatsoever? This question touches on a related organisational design issue – that of departmentalisation. Departmentalisation represents the degree to which the organisation is divided, or segmented into different subsystems (Lawrence and Lorsch, 1967). The basic premise is that differentiated units are more oriented towards their specific environment or tasks and therefore perform better. This factor and the important issue of closeness to customers (internal and external) have not been addressed in this study. Therefore, extending this study to also address the question of departmentalisation of is the natural next step to expand knowledge in intrafirm R&D organisation.

6 Conclusions and managerial implications

Foremost, these case studies show that firms may organise product and process innovation differently in terms of the degree of centralisation. In that sense the conventional notion of R&D organisational design, equating R&D more or less with product innovation, does not present the complete picture. In this study it is illustrated that R&D can work under dual structures, which is not apparent when R&D is considered more or less synonymous with product innovation. Hence, it is shown that the R&D organisation can be seen as one structure for product innovation and one structure for process innovation.

The study also accentuates the importance of a firm’s expectations on innovation and how these expectations are linked with the structure of the organisation. Depending on the importance of creating and developing resources and competencies, the broadness of application, and the radicalness of technology the firm must make choices on organisational
structures for product and process innovation. The R&D organisation must be consistent with the expectations of R&D i.e. there must be an internal fit between strategy and structure.

Managers can use the matrix to discuss what kind of knowledge the firm is actually looking for (competence-deepening or competence-broadening) with respect to process innovation and product innovation. Managers can also think about if it is reasonable to assume that the current approach to intrafirm R&D will deliver the knowledge requested. By thinking about the model for centralisation or decentralisation of intrafirm R&D and understanding a firm’s position in the matrix managers can be helped in opening up their intrafirm R&D organisation and also to avoid some of the most obvious pitfalls in organising innovation.

7 References


