OLD SWEDISH BUSINESS IN NEW INTERNATIONAL CLOTHES

CASE STUDIES ON THE MANAGEMENT OF STRATEGIC RESOURCES IN FOREIGN-ACQUIRED SWEDISH R&D FIRMS

Angelina Sundström

2015

School of Business, Society and Engineering
OLDSWEDE BUSINESS IN NEW INTERNATIONAL CLOTHES

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Akademisk avhandling

som för avläggande av teknologie doktorsexamen i industriell ekonomi och organisation

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Fakultetsopponent: Docent Jim Andersén, Högskolan i Skövde

Akademin för ekonomi, samhälle och teknik

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Abstract

Which conditions are needed for research and development firms to stay competitive? Such firms must continually develop new products and processes if they are to provide their customers with value, and equal, if not exceed, the offerings their competitors provide. Firms that lack sufficient innovation and creativity risk losing customers, their reputation, and their position in corporate structures and in their industries. Even worse, they may be forced to liquidate their assets, file for bankruptcy, merge with other divisions, or be sold. There are many possibilities, and few of them can be said to be positive for the firm, its owners, or its employees. However, this thesis tells the story of how a Sweden-based firm, which was divided and sold to foreign, multinational corporations, survived as three separate research and development firms in southern Sweden. It examines how these three firms (all working in air handling technology) built on their historic legacy and continued as significant players in their industry.

The analysis takes a resource-based view in its examination of the firms’ competitive advantage derived from its resources and resource management. The examination is based on Jay Barney’s VRIN framework and Robert Simons’s Levers of Control framework. The analysis identifies and describes the firms’ technical, financial, human and relationship resources, and analyses whether these resources are strategic or complementary. It confirms previous research that finds research and development firms can stay competitive if they have strategic resources such as test facilities, employees with expertise and experience, and strong relationships with suppliers and customers. It also finds that complementary resources such as information technology contribute to the competitiveness of research and development firms.

The contribution of this thesis to previous research is its analysis of the significant role management control has in managing the resources of research and development firms. The thesis develops a management control model for such firms – the Integrated Resource Management model – that has four alternatives resource management strategies. These strategies are: Bureaucratic Resource Management, Structured Resource Management, Flexible Resource Management, and Explorative Resource Management.
To Mom and Dad
Acknowledgements

I began my research process in the Autumn 2007 on a visit to the ‘real world’ away from the university. I have now made many trips to Växjö in southern Sweden. I can state that Växjö is a very wet city. I recommend that visitors carry an umbrella whenever they visit Växjö!

I researched and wrote my thesis in the Industrial Renewal graduate programme, which is a collaborative venture between Mälardalen University and Örebro University. The Swedish School of Management and Information Technology (MIT) provided financial support and mentors.

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Thank You!
Tack!
Obrigada!

Angelina Sundström

New York
21st May 2015
ABSTRACT

Which conditions are needed for research and development firms to stay competitive? Such firms must continually develop new products and processes if they are to provide their customers with value, and equal, if not exceed, the offerings their competitors provide. Firms that lack sufficient innovation and creativity risk losing customers, their reputation, and their position in corporate structures and in their industries.

Even worse, they may be forced to liquidate their assets, file for bankruptcy, merge with other divisions, or be sold. There are many possibilities, and few of them can be said to be positive for the firm, its owners, or its employees. However, this thesis tells the story of how a Sweden-based firm, which was divided and sold to foreign, multinational corporations, survived as three separate research and development firms in southern Sweden. It examines how these three firms (all working in air handling technology) built on their historic legacy and continued as significant players in their industry.

The analysis takes a resource-based view in its examination of the firms’ competitive advantage derived from its resources and resource management. The examination is based on Jay Barney’s VRIN framework and Robert Simons’s Levers of Control framework. The analysis identifies and describes the firms’ technical, financial, human and relationship resources, and analyses whether these resources are strategic or complementary. It confirms previous research that finds research and development firms can stay competitive if they have strategic resources such as test facilities, employees with expertise and experience, and strong relationships with suppliers and customers. It also finds that complementary resources such as information technology contribute to the competitiveness of research and development firms.

The contribution of this thesis to previous research is its analysis of the significant role management control has in managing the resources of research and development firms. The thesis develops a management control model for such firms – the Integrated Resource Management model – that has four alternatives resource management strategies. These strategies are: Bureaucratic Resource Management, Structured Resource Management, Flexible Resource Management, and Explorative Resource Management.
Sammanfattning

Vilka villkor behöver uppfyllas för att forsknings- och utvecklingsföretag ska förblivi konkurrenkskraftiga? Sådana företag måste ständigt utveckla nya produkter och processer, som är likvärdiga eller bättre än konkurrenternas, som de kan att erbjuda sina kunder. De företag som misslyckas med att vara tillräckligt innovativa och kreativa riskerar att förlova sina kunder, sitt rykte, och sin position inom koncernen och i sin industri.


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Chapter 1: INTRODUCTION

1.1 The Globalisation of Swedish Businesses

Today there is an on-going debate about the changes resulting from global markets and competition and the effect of these changes on the business environment. While globalisation has drawn the people of the world closer, it has also created new challenges for successful firms. In the past, firms thought it was sufficient simply to offer products and services routinely to their customers. However, in today’s competitive global markets, products and processes may quickly become obsolete due to rapid changes in customers’ demands/preferences and in technological developments. Therefore, all firms must realise the importance of making frequent improvements in their existing products and processes and of developing new ones. Firms that do not meet this challenge by conducting research and development (R&D) activities may not survive in the global market.

This study focuses on Swedish industrial firms that have survived in the globalised economy in which survival depends on meeting the competition and being innovative. Firms that cannot meet these challenges should be discontinued or restructured. This study contributes to our knowledge of how R&D firms stay competitive as they develop and market their products and processes, taking into account the on-going rationalisation and specialisation in certain industries and sectors.

In the discussion of Swedish industrial success, various innovation-oriented firms founded in or around the beginning of the 20th century are often mentioned. These firms include Ericsson (1876), ASSA (1881), ASEA (1883), Alfa Laval (1883), SKF (1907), and Kreuger & Toll (1908). Each of these firms became a major industrial player in the Swedish economy.

Some of these firms have survived while others, for various reasons, have not. In practice, the restructuring of firms may take different forms: joint ventures, mergers, or acquisitions (Bowman & Singh, 1993; Schriber, 2008). Restructuring may also occur when firms, or firms’ departments/groups, are relocated to other
countries. In such cases, the goal may be to gain market share, to increase sales, and/or to acquire and upgrade resources that complement the firms’ resource bases.

In recent years, some firms have relocated their R&D operations to foreign countries. For example, in early 2012 Astra Zeneca, the British-Swedish multinational pharmaceutical and biological company, announced it would reduce its R&D in the neuroscience field (i.e., a field focused on Alzheimer’s disease, stroke, etc.) and at the same time move its R&D operations to a minor sub-unit located outside Sweden.

Financial considerations at the corporate level often motivate certain changes resulting from increased global competition. For instance, Astra Zeneca’s intention, among others, was to improve its R&D capabilities (Astra Zeneca, press release, 2012). However, the decision meant that Sweden lost around 1100-1200 jobs. In August 2012, Sweden received news of another relocation when Sony Mobile moved its corporate headquarters and certain other functions (e.g., hardware development) from Sweden to Japan (Sony Corporation, press releases, 2012).

In some cases, specific departments/groups may benefit more from such relocations than their firms’ employees or their general operations. Although Sony Mobile retained its software development in Sweden, its operations in Lund, Sweden, no longer existed as a complete development system. Sweden lost an additional 650 jobs (Sony Corporation, press release, August, 2012). According to Kunimasa Suzuki, President and CEO of Sony Mobile, the reason for the relocation was to create a more efficient operational structure that would reduce firm costs, enhance market efficiency, and strengthen the business (Sony Corporation, press release, 2012).

1.1.1 Addressing Global Competition: The Quest for R&D
This study describes how R&D firms stay competitive. It examines three R&D organisations that were originally parts (i.e., sub-units) of one firm. Each was acquired by a foreign corporation and is still located in Sweden. In this study, R&D is seen as a strategy aimed at the renewal and development of a firm’s products and processes that may enhance its position in the global market. Successful competition derives from the adoption and implementation of R&D strategies.
Theories of innovation, which build on the work of Joseph Schumpeter, stress that innovation is one way to approach global competition. According to the literature, firms need to innovate to stay ahead of their competitors. Therefore, they should adopt a strategy that places innovation at the forefront. R&D (i.e., how to develop a product or process) is often linked with innovations, which are described as sources of economic growth, investment capital, and employment (Ottosson, 1999b, p. 26; Tidd & Bessant, 2009, p. 5).

Innovations also have the potential to make firms with competitive and profitable by offering consumers new and improved products and processes (e.g., Brown & Eisenhardt, 1995; Ottosson, 1999b, p. 52; Tidd & Bessant, 2009, p. 5). To contribute to national economic growth and to meet the changing needs of the global market, established firms must update their existing products and processes frequently as well as develop new ones (Johne & Snello, 1988; Ottosson, 1999a, pp. 35-36; Ulrich & Eppinger, 2008, p. 2).

Inspired by Godner and Söderquist (2004), this study uses the term R&D (i.e., New Product Development [NPD]) to describe the spectrum of activities comprised of advanced engineering, product development, and process development. The R&D literature contains empirical and theoretical discussions from different perspectives on how firms develop these products and processes. Researchers who have focused on the development of products and processes range from organisation managers to economists and historians. These researchers are concerned with innovation in R&D as well as how individual scientists and engineers, in addition to entire organisations, process information or solve problems related to design, engineering, and manufacturing (Cusumano & Nobeoka, 1992). R&D is a multidisciplinary research field,¹ and it is difficult to find a clear distinction in the literature between R&D and NPD. According to Godner and Söderquist (2004), researchers use the term R&D for fundamental research and NPD for commercialisation.

This study takes a Research-based View (RBV) of R&D. One of the essential areas in the R&D literature is the focus on the critical success factors in R&D (e.g., Cooper, 1999; Song & Noh, 2006; Samaan, Salgado, Sanches da Silva, & Mello, 2012). Although different researchers focus on different industries, one

¹ For example, there are at least four identifiable perspectives in the field: marketing, organisations, engineering designs, and operations management (Krishnan & Ulrich 2001; Page & Schirr, 2008).
recurring theme in their studies is that an R&D firm’s ability to perform successful development depends on its resources. These studies have adopted a RBV of the firm.

In the RBV, a traditional definition of the term resource is “anything which could be thought of as a strength or weakness of a given firm” (Wernerfelt, 1984, p. 172). The assumption is that a firm can gain competitive advantage and, in time, sustainable competitive advantage by controlling a distinctive bundle of resources (Barney, 1991; Conner, 1991; Peteraf, 1993).

Researchers who take the RBV see resources as inputs to development performance and as explanations of success. They identify several resources and capabilities that may affect development performance. These resources include the following: technical resources (e.g., engineering and production), financial resources (e.g., external and internal funds), marketing resources (e.g., marketing research, advertising, and promotion), human resources (e.g., management, technical experts, and teams), knowledge and skills resources (e.g., technical and scientific), and relationship resources (e.g., customers and suppliers). The capabilities include innovation capabilities, technical capabilities, marketing capabilities, and manufacturing capabilities (e.g., Brown & Eisenhardt, 1995; Del Canto & González, 1999; Verona, 1999; Krishnan & Ulrich, 2001).

However, there are researchers who stress that resources do not mean much by themselves, and have criticised the RBV for its static focus on resources (e.g., Teece, Pisano, & Shuen, 1997). According to these researchers, firms depend on resources and the capability to exploit resources by combining them in organisational processes that achieve desired results (Grant, 1991; Penrose, 1959/2009; Helfat & Peteraf, 2003; Akio, 2005).

Keeping in mind the fact that the RBV assumes firms are profit-maximising entities, it is surprising that the RBV has been criticised for overlooking management’s ability to use firm resources as a catalyst for competitive advantage (e.g., Mahoney, 1995) and for neglecting, for example, processes and people’s actions (Whittington, 2002; Johnson, Langely, Melin, & Whittington, 2007; Höglund & Sundström, 2011; Höglund, 2013).

To understand firms’ economic success, it is necessary to consider both their resources and the influence of Resource Management on performance and competitiveness. With its assumption that it is not enough for firms to only control distinctive resources to achieve competitive advantage (Barney, 1991), this study
argues that the RBV is unable to provide a complete understanding of Resource Management in its association with the firm’s capacity to exploit resources.

This study also takes a Management Control perspective. RBV researchers have suggested that proper Resource Management is conducted through organisational components such as the firm’s management control system (e.g., Barney, 1995; Barney & Mackey 2005, p. 10; Barney & Clark, 2007, p. 67; Barney & Hesterly, 2008, p. 90). However, previous studies on R&D have pointed out that R&D activities are unique, creative, and unstructured, and that management control may discourage creativity (Amabile, Conti, Coon, Lazenby, & Herron, 1996; Amabile, 1998). In recent year others argue that it is not enough for management simply to ‘believe’ their R&D is a good investment. Instead, management must control R&D activities (Davila, 2000; Cardinal, 2001; Cedergren, 2011) in order to use them in the strategic objectives of the firm (Simons, 1994; Kerssens-van Drongelen & Bilderbeek, 1999; McCarthy, Johnson, & Gordon, 2011; McCarthy & Gordon, 2011).

Because of its special characteristics, R&D requires different management control approaches than other business functions (Rockness & Shields, 1984, Abernethy & Brownell, 1997; Kerssens-van Drongelen & Cook, 1997; Kerssens-van Drongelen & Bilderbeek, 1999). This means that management must ensure that the firm conducts its R&D activities in a way that provides consumers with new, needed, and improved products and processes. In addition, management must also consider the design of the firm’s management control that supports the resource management (i.e., the resource exploitation).

Although this is acknowledged as important, the majority of studies on R&D management mainly focus on performance measurements (Godener & Söderquist, 2004; McCarthy et al., 2011; Chiesa & Frattini, 2007) that are part of management control. Few R&D management studies have recognised the need to examine how the whole range of management control works together (Malmi & Brown, 2008; McCarthy et al., 2011) to exploit the full competitive potential of firm resources as firms try to achieve competitive advantage.
1.1.2 Research Question and Research Aim

R&D activities can provide benefits at the level of countries and firms. However, this requires that R&D firms stay competitive. Therefore, this study poses the following research question:

Which conditions are needed for R&D firms to stay competitive?

In this study, an R&D firm is considered competitive when it has successfully managed external and internal competition over time, and thereby defended its position in the market and its internal position in its industrial group.

In order to answer this research question, it is necessary to understand how resources contribute to R&D firms’ competitiveness and how management control is used to manage these resources. Previous studies find that the firm’s resources support its competitiveness in its industry sector (Wernerfelt, 1984; Barney, 1991; Grant, 1991; Peteraf, 1993) and its capacity to exploit resources using organisational processes (Penrose, 1959/2009 Grant, 1991; Helfat & Peteraf, 2003).

Inspired by the discussion on resources and resource management, this study considers it is important to discuss the development progression of the RBV in a more holistic way. This discussion involves the firm’s internal strength as it competes in the market. Thus, the aim of this study is the following:

To contribute to the RBV with regard to resource management processes at R&D firms.

The literature on the RBV and Management Control in the context of R&D is reviewed, followed by the development of a framework for analysing the resources and management of resources. This thesis, which takes a qualitative approach, begins with an analysis of the resources used by three R&D firms (i.e., the sub-units) that are located in the same city in southern Sweden. Three different multinational corporations acquired these firms. Thereafter, the firms’ management of their resources as they try to stay competitive is analysed. The thesis concludes with a discussion of the findings, conclusions, and implications for practitioners. See Figure 1.
1.2 Outline of the Thesis

The outline of the thesis is illustrated in the figure below.

Figure 1: Outline of the Thesis
Chapter 2: COMPETITION AND RESOURCES

The chapter begins with a presentation of the RBV and a description of how firms can achieve sustainable competitive advantage through by using their resources. Thereafter, the chapter reviews the RBV in the field of R&D. The chapter ends with a summary of the literature on the RBV as the basis of successful R&D.

2.1 Competitive Advantage through Resources

In strategic management research, there are different suggestions on how a firm can succeed in the global market. By the 1980s, much of the emphasis was on the external environment – that is, on the firm’s competitive and global position (Barney, 1991; Collins & Montgomery, 2008). After Porter’s work on competitive advantage, which was a breakthrough in the field of management strategy (e.g., Porter, 1980, 1985, 1986), researchers were concerned primarily with analysing a firm’s opportunities and threats in its competitive environment (Barney, 1991).

Taking an industrial and organisation economics perspective, Porter (1986, pp.17-18) suggests that the core advantage occurs in the market place where firms achieve competitive advantage by using a competitive strategy. Although Porter does not ignore the characteristics of individual firms, his main focus is at the industrial level (Collins & Montgomery, 2008). Little attention is given to how firms can assess either the resources themselves or the market opportunities in systematic ways (Foss, Knudsen & Montgomery, 1995, p. 7).

However, some strategy researchers, in returning to the work of Kenneth Andrews (1971), began to explore issues concerning the firm itself. This perspective, which is known today as the RBV, is seen as a useful complement to Porter’s industrial structure perspective on strategy and his five forces model. Before the 1980s, this was a core framework for envisioning the competitive strategy of the firm.
In contrast to the previous conventional strategy research, which had benefited from the insights of industrial organisational economics (Black & Boal, 1994), RBV researchers brought a systematic approach to firm-level analysis (Foss et al., 1995, p. 7) and began to focus on internal aspects of the firm that allow it to compete in a competitive environment (Miller & Shamsie, 1996). Rumelt (1995, p. 102) explains:

We envision the firm as striving to maximize value, but also to see it as working with factors of production that are far from mobile, as dealing with ambiguous production functions, and as possessing or controlling collections of tacit knowledge and externally held attributions (reputation) that evolve over time in response to investment, activity and imitation.

In other words, the RBV complements Porter’s perspective because it emphasises the internal aspect of the five forces model analysis in the formulation of a firm’s strategy.

Since the 1980s, the RBV has grown within the strategy management literature through the efforts of several researchers. The RBV is concerned with the firm at the firm level (Wernerfelt, 1984; Barney, 1991) and has been used to address questions such as why firms differ and how firms can gain sustainable competitive advantage. Writers on business strategy, such as Kenneth Andrews (1971) (i.e., strategy as a fit between a firm’s strength and weaknesses and opportunities and threats in the environment), Alfred Chandler (1962) (i.e., structure follows strategy), and Edith Penrose (1959/2009) (i.e., the firm as a collection of productive resources) have largely shaped the RBV. Thus, several researchers have contributed to the development of the RBV. Today, the RBV is a significant and useful theoretical framework in the field of strategic management (e.g., Wernerfelt, 1984; Barney 1986, 1991; Dierickx & Cool, 1989; Prahalad & Hamel, 1990; Amit & Schoemaker, 1993, Peteraf, 1993; Teece et al., 1997; Eisenhardt & Martin, 2000; Lavie, 2006).

2.1.1 Firm Resources
Recognising that differences exist among firms, the RBV stresses that such differences lie in their resources. The assumption of the RBV is that the desired outcome of a firm’s managerial efforts is sustainable competitive advantage, and by achieving sustainable competitive advantage firms are able to earn economic rents or above average returns. Therefore, one of the main questions in the RBV
is the question of how firms can achieve a competitive advantage that is sustainable. Viewing the concept of strategy as a continuing search for rents² (Bowman, 1974, in Mahoney & Pandian, 1992, p. 364), the RBV suggests that a firm’s strategic competitiveness is a function of bundle of strategic resources that the firm controls (Barney, 1991; Conner, 1991; Peteraf, 1993).

Thus, the RBV draws on the premise that competitive advantage, sustainable competitive advantage, and rents derive from a range of resources. In the RBV, resources are the core element and the basic unit of analysis. Various researchers have offered definitions of the term “resource” (e.g., Wernerfelt, 1984; Rumelt, 1984). However, these researchers have described resources quite broadly to include, for example, assets, knowledge, capabilities, and processes.

Wernerfelt’s (1984) article on the RBV is considered one of the first RBV publications in the strategic management field. Wernerfelt describes resources as anything that can be either a strength or a weakness for the firm. Examples of such resources are patents, brand names, reputation, in-house knowledge of technology, employment of skilled personnel, trade contracts, machinery, efficient procedures, capital, etc. (Wernerfelt, 1984, 1989).

Barney (1991) defines firms’ resources as all firm-controlled assets, capabilities, organisational processes, attributes, information, and knowledge that can help the firm to implement and maintain strategies that improve its efficiency and effectiveness. Grant (1991) defines resources as inputs into the production process – equipment, employee skills, patents, brand names, and financial assets. Based on previous definitions of resources (e.g., Wernerfelt, 1984; Barney, 1991) Barney and Arikan (2001, p. 138) offer a more current definition of resources as “tangible and intangible assets firms use to conceive of and implement their strategies” (p.138).

² There are different kinds of rents. Examples are Ricardian rents, Monopoly rents, and Entrepreneurial (Schumpeterian) rents (Mahoney & Pandian, 1992; Peteraf, 1993; Barney & Arikan, 2001, pp. 127-130; Alkio, 2005; Alvarez & Busenitz, 2001; Alvarez, 2007). Ricardian rents derive from the ownership of scarce valuable resources (Ricardo, 1817, pp. 55-58), such as valuable land, advantageous locations, patents, and copyrights (Mahoney & Pandian, 1992). Monopoly rents may be achieved by governmental protection or collusive arrangements (Mahoney & Pandian, 1992). Peteraf (1993) explains that the difference between Ricardian rents and Monopoly rents is that Monopoly rents are based on a deliberate restriction of output, and not by a limited resource supply. Entrepreneurial rents (i.e., Schumpeterian rents) are rents that may be achieved by entrepreneurial insight and risk-taking (Alvarez & Busenitz, 2001; Alvarez, 2007).
2.1.1.1 Categorising Firm Resources
In the RBV field, it is common to classify resources into categories such as physical resources, human resources, and organisational resources (Barney, 1991; Grant, 1991) and financial resources (Grant, 2010).

Resources can also be classified as tangible and intangible resources. For example, Grant (1991) describes tangible resources as assets that can be identified on the firm’s balance sheet whereas intangible resources are the differences between the firm’s assets as reported on the balance sheet and their market values. Wilk and Fensterseifer (2003), however, describe tangible resources as resources that are observable, and intangible resources as resources that cannot be directly observed or quantified.

Examples of tangible resources include physical assets such as buildings, equipment, natural resources, and raw materials (Grant, 1991) and financial assets such as stocks and bonds, claims, and bank deposits (e.g., Fahy 2002). Examples of intangible resources include the firm’s intellectual property, reputation, brand equity, and product quality (Grant, 1991; Hall, 1992; Fahy, 2002).

Other examples of intangible resources are knowledge assets (i.e., skills, competencies, experience, and know-how in, for example, productive, technical, and managerial personnel) as well as organisational culture, training, and loyalty (e.g., Grant, 1991; Hall 1992; Bharadwaj, 2000; Wilk & Fensterseifer, 2003).

2.1.1.2 Resources not fully owned or controlled by the firm
It was stated at the beginning of this chapter that the RBV focuses on the internal resources the firm uses to achieve competitive advantage and sustainable competitive advantage (Wernerfelt, 1984; Dierickx & Cool, 1989; Barney, 1991; Miller & Shamisie, 1996). However, as the field has developed, more recent studies suggest that the sources of a firm’s competitive advantage are in part external to the firm (Gulati, Nohria, & Zahere, 2000; Lavie, 2006, 2007).

With reference Granovetter (1985) and others, Gulati et al. (2000) point out that a firm is embedded in networks of social, professional, and exchange relationships with other organisational actors. According to these researchers, such networks are comprised of both horizontal and vertical relationships with other external actors such as suppliers and various entities across industries and countries.

Network relationships may provide several benefits for the focal firm. Gulati et al (2000, p. 203) write:
We highlight the idea that strategic networks potentially provide a firm with access to information, resources, markets and technologies; with advantages from learning, scale and scope of economies; and allow firms to achieve strategic objectives, such as sharing risks, outsourcing value-chain stages, and organisational functions.

Departing from Gulati et al.’s (2000) study, Lavie (2006) claims that interconnected firms can extract value from resources that are not fully owned or controlled internally by the firm. This is a view that is contrary to the conventional RBV studies and can be understood as a development of the RBV. By distinguishing between shared resources and non-shared resources, Lavie’s study identifies new types of rents and shows how firm-, relation-, and partner-specific factors determine the contribution of network resources to the rents extracted from networks.

Lavie’s study (2006) shows that firm valuation should be based not only on resources within the firm’s boundaries, but also on the resource contributions of its partners. Lavie explains:

As Conner (1991) has concluded, firm performance results from simultaneous interactions among the firm’s resources, the resources of its competitors, and the public policy environment. Assumed away is a cooperative type of interaction, in which the superior resources of counterpart firms can actually contribute to the focal firm’s performance. (p. 641)

2.1.2 Identifying Strategic Resources

According to the RBV, some resources are more “strategic” than others because they provide firms with sustainable competitive advantage (Barney 1991; Peteraf, 1993). The premise is therefore that resources are of different importance and have different potential as sources of sustainable competitive advantage. However, researchers have acknowledged that it difficult to determine beforehand which firm resources lead to sustainable competitive advantage given the inherent uncertainty that exists in the business environment (Fiol, 1991; Peteraf, 1993; Black & Boal, 1994).

Researchers such as Barney (1991), Grant (1991), Peteraf (1993), and Amit and Schoemaker, (1993) have addressed this issue by presenting criteria that can be used to identify strategic resources. Barney and Clark (2007, pp. 14-17) explain
that the papers published by these researchers are founded on the basic principles of RBV previously presented by Wernerfelt (1984), Rumelt (1984), Barney (1986) and Dierickx and Cool (1989).

For example, Grant (1991) identifies the following characteristics of strategic resources: durability, transparency, transferability, and replication. Amit and Schoemaker (1993) identify eight features of strategic resources: complementarity, scarcity, low tradability, inimitability, limited substitutability, appropriability, durability, and overlap with industry factors. Fahy (2000) presents a detailed review of the literature and writes that strategic resources are commonly described as immobile, untradeable, and inimitable. Although the RBV researchers use different words to describe strategic resources, their ideas are generally similar (Wilk & Fensterseifer, 2003). One commonality is that it is not enough for the resources to produce only economic value to be classified as strategic resources.

Although these researchers have described the characteristics of strategic resources, Barney’s (1991) framework is the most common and well-known model of strategic resources. Barney lists four attributes of the potential for firms to generate sustained competitive advantage; Value, Rare (scarcity), Imperfect Imitability, and Non-Substitutability—these are the so-called VRIN attributes.

Whether they are tangible or intangible, resources are strategically relevant only if they help firms conceive and implement strategies that improve their efficiency and effectiveness. If a resource doesn’t produce such results, it cannot be considered a strategic resource (Barney, 1991; Barney & Arikan, 2001, pp. 141-142; Barney & Mackey, 2005, p. 2). In other words, resources must have value, that is, some capacity to generate profit or prevent losses (Black & Boal, 1994).

The first criterion, Value, which focuses on the worth of resources, attempts to determine if a particular resource and capability can address environmental threats and opportunities (Barney 1991,1995; Barney & Arikan, 2001, pp. 141-142; Barney & Hesterly, 2008, p. 85). Value is defined as the fit of firm’s resources to its strategy combined with the fit between the firm’s strategies and its external environment (Barney, 1991; Boal & Black, 1994; Barney & Mackey, 2005, p. 2).

In describing the Value attribute, Barney (1991, 1995) and Barney and Clark (2007, p. 51) link the internal analysis of strength and weakness with the external analysis of threats and opportunities. The firm’s resources are considered to have strength when the firm can use them to exploit environmental threats and opportunities. They are considered weak when it is difficult for the firm to use them
to exploit environmental threats and opportunities. This means that a firm’s value is determined by exploring the benefits it provides in the market. Barney and Mackey (2005, pp. 2-3) stress that a researcher should examine the value of a firm’s strategies when calculating the potential value of its resources. They write: “This work suggests an approach to linking resources to strategy and thereby examining the potential of resources to create economic value by enabling firms to create and implement strategies”.

The second attribute, Rare (or scarcity) refers to a firm’s resources that competitors lack (Barney, 1991). Barney (1991,1995) claims if competitors have many of the same valuable resources, then they cannot be considered resources that provide competitive advantage or sustainable competitive advantage. Resources are rare if the demand for them is higher than their supply. Thus, a resource’s rarity depends on the combination of physical scarcity in the market and/or the rarity of the resource’s perceived value because of some particular resource combination in the firm (Black & Boal, 1994). However, some competitors may possess a particular resource without loss of rarity. In that case, the number of such resources should be less than required for perfect competition (Barney & Arikan, 2001, p. 144).

The third attribute, Imperfect Imitability, refers to the extent to which a resource can be imitated or copied (Barney, 1991,1995). A basic assumption is competitors will imitate another firm’s strategic resources. Barney claims that valuable and rare resources can only be sources of sustainable competitive advantage if competitors do not have these resources and cannot obtain them. This means that resources that are valuable, rare, and difficult to copy (e.g., costly-to-imitate) may be sources of competitive advantage (Barney & Hesterly, 2008, p. 85).

Imitation can occur in at least two ways. A resource can be duplicated (i.e., imitated) or substituted (Barney, 1995; Barney & Hesterly, 2008, p. 86). In this way, the fourth attribute, Non-Substitutability, focuses on a resource’s substitutability. Resources that are substitutes reduce rents because they make monopolistic or oligopolistic demand curves more elastic (Peteraf, 1993). Barney and Mackey (2005, p. 6) describe the problem with strategies:

By their nature, strategies are relatively public. That is, when a firm implements its strategies, it is usually not very long before other firms are able to articulate what those strategies are.
This statement implies that resources are non-substitutable if they can be uniquely used to help a firm develop and implement its strategy (Barney 1991,1995). It also means that competitors cannot reproduce the same product or the process from a similar, substitutable resource.

As Andersén (2005, p. 32) observes, no resource can be substituted exactly, but its strategic importance can. Barney and Arikan (2001, p. 145) explain:

If the number of firms that possess these substitute resources is large, then the strategies that are associated with them are not rare, and not a source of superior performance. If the number of firms that possess these substitutes is small, they can still have competitive advantage implications

2.1.2.1 Protection from Imitation
According to Barney (1991,1995), there is more than a single way for firms to protect their resources from imitation. Barney uses the terms History Dependent, Causal Ambiguity, and Social Complexity. See Figure 2.

![Figure 2: Modified figure based on Barney’s VRIN framework (Barney, 1991, p. 112)](image)

History Dependent refers to the history of a firm’s past decisions and activities. Like traditional strategy researchers (e.g., Ansoff 1965), the RBV recognises firm performance and competitiveness, and acknowledges that a firm’s ability to use its resources competitively depends on a unique time advantage (Barney, 1991; Barney, 1995; Barney & Clark, 2007, p. 60). Barney (1991, p. 108) explains:
If a firm obtains valuable and rare resources because of its unique path through history, it will be able to exploit those resources in implementing value-creating strategies that cannot be duplicated by other firms, for firms without that particular path through history cannot obtain the resources necessary to implement the strategy.

Thus, due to a firm’s unique historical conditions (e.g., culture or geographic location), competitors are prevented from acquiring the same resources. Research shows that as firms evolve, they acquire skills, abilities, and other resources. According to Barney (1995), these resources, which are firm-unique, reflect a firm’s path through history as well as its personality, experience, and relationships. In this way, the RBV highlights a firm’s history as an important isolating mechanism useful in preventing competition (Barney 1991,1995), because space- and time dependent resources are Imperfectly Imitable (Barney & Clark, 2007, p. 60)

According to Lippman and Rumelt (1982), resources that are causally ambiguous are more costly to imitate than resources that are not causally ambiguous. Causal Ambiguity means that competitors are unaware of, or do not understand, the link between a firm’s resources and its sustainable competitive advantage. Thus, competitors find it difficult to duplicate a firm’s strategies because they do not know which resources they should imitate (Barney, 1991). Casual Ambiguity appears in two forms. The first form is that the actual linkage between resources and their sustainable competitive advantage is unknown. The second form is that which actually creates the sustainable competitive advantage is the actual resource (Andersén, 2005, p. 34).

However, there is a problem with Causal Ambiguity, although it has been pointed to as one of the most important isolating mechanisms (Wilk & Fens terseifer, 2003). As Lippman and Rumelt (1982) and Barney (1991) observe, the firm that possesses strategic resources is often unaware of the link between those resources and their sustainable competitive advantage. That is why firms should have an understanding of the link. When one firm can identify the linkage, there is a risk that this information will spread to other firms.

Resources may have Imperfect Imitability because of Social Complexity – in other words, because of complex social phenomena that firms cannot manage or influence. These socially complex resources can create an important base for the firm’s competitive advantage despite the fact that competitors may be aware of the linkage between the firm’s socially complex resources and its competitive advantage (Barney, 1991).
There are a variety of resources that may have Imperfect Imitability because of their Social Complexity. Among these resources are culture, relations, and reputation (Barney, 1991). However, Barney notes that this does not mean that the resources exploited by Social Complexity are socially complex themselves. For example, even if exploitation of a physical technology may involve resources categorised as socially complex (e.g., a firm may have the social relationships, cultures, and traditions that allow it to exploit the technology), this technology should not be seen as socially complex. Barney argues that this is a fact, regardless of whether the physical technology consists of machine tools, factory robots, or information management systems. All are imitable. Barney (1991) explains:

If one firm can purchase these physical tools of production and thereby implement some strategies, then other firms should also be able to purchase these physical tools, and thus such tools should not be a source of sustained competitive advantage. (p. 110)

Other researchers have also pointed out that resources may be Imperfectly imitable because of information asymmetries and legal protection (Andersén 2005, pp. 34-35). Information asymmetries refer to information asymmetries both among competitors (e.g., firms have different perceptions of resources’ value) and among customers (e.g., customers perceive attributes of products differently). Legal protection refers to, for example, contracts, copyrights, and patents.

In practice, competitors may have resources that are categorised as Valuable, and even Valuable, Rare, and Imperfect imitable (i.e., V or VRI). Yet such resources do not have the fourth attribute of the VRIN framework (Non-Substitutable). These resources are called complementary resources (Barney, 1995; Barney & Clark, 2007, p. 67). However, according to the VRIN framework, competitors cannot outperform other firms by the mere ownership of such resources. Barney’s (1991) VRIN framework is based on the idea that only the resources that are Valuable, Rare, Imperfectly imitable and Non-Substitutable are the strategically relevant resources that can result in competitive advantage and sustainable competitive advantage. Fundamentally, the strategic resources that the RBV addresses are the resources that differentiate firms from one another.
2.2 Research on Resources in R&D

There are R&D researchers who have embraced the RBV of the firm. These researchers base their conclusions on the premise that a firm’s capacity to conduct successful R&D depends on its resources and capabilities. Thus, resources and capabilities underlie and determine product development performance. The researchers who have embraced this perspective consider both tangible and intangible resources as contributors to the product development process. The firm’s capability for developing new and improved products then exploits this process.

The RBV literature has identified several resources: technical resources (e.g., R&D, engineering, and production), financial resources (e.g., external and internal funds), marketing resources (e.g., marketing research, advertising, and promotion), human resources (e.g., management, technical experts, and teams), knowledge and skills resources (e.g., technical and scientific), relationship resources (e.g., customers and suppliers), and capabilities (e.g., innovation capabilities, technical, marketing, and manufacturing capabilities). These resources (and capabilities) have the potential to influence product development (Brown & Eisenhardt, 1995; Verona, 1999; Del Canto & González, 1999; Krishnan & Ulrich, 2001). Although they are often grouped and discussed in different terms, these resources (and capabilities) are consistently linked to activities in the product development process (Kleinschmidt, Brentani, & Salomo, 2007).

2.2.1 Human Resources

An organisation is usually described in terms of its carefully planned, pre-development activities that it performs in coordinated and cross-functional teams (i.e., teams composed of members with diverse functional specialties and access to diverse information). Management supports such teams that enhance a firm’s synergies (Brown & Eisenhardt, 1995).

Various authors stress the dependency of R&D activities on human resources, that is, on people (e.g., Cooper & Kleinschmidt, 1986; Tushman & Nadler, 1986; Song & Noh, 2006; Vieites & Calvo, 2011). Human resources include the people who actually do the R&D work (e.g., product design, development, and commercialisation), senior managers and managers who review the development process, and other people who contribute to the progress of the firm’s development process. Kandemir, Caltone, and Garcia (2006) draw on the RBV of the firm to explore the effect resources have in the development process activities in the
biochemistry industry. They think people are important resources for implementing and maintaining product development projects. They refer to management commitment, strong champions, multi-disciplinary teams, and team focus.

It is assumed that R&D activities require communication among managers, project team members, and external actors. The better the communication, the more successful the R&D. The increased complexity of R&D seems to have created a need for knowledge sharing across the organisation (Nambisan & Wilemon, 2000). Studies have shown that cross-functional development teams, which are important for good communication and knowledge sharing, are important resources for innovation and learning across projects (Ibid.).

Fredericks (2005) refers to the human resources perspective in her focus on cross-functional teams in the development process. She describes project teams as important resources for the development process because team structure can be “an alliance of highly interdependent, cross-functional representatives with varying expertise directly collaborating and sharing resources in the form of information, schedules, procedures and processes [...]” (p. 328)

In other words, teams are groups of human resources with different functional specialisations (e.g., R&D, manufacturing, and marketing). Team members can provide a diversity of inputs (Song & Montoya-Weiss, 1998; Fredericks, 2005; Song & Noh, 2006). The claim is that the involvement of many functional specialists – marketing and R&D specialists as well as design and manufacturing specialists – develops firm-specific knowledge over time (Brown & Eisenhardt, 1995; Song & Noh, 2006). The path dependency of such knowledge offers protection from competitors (Nelson & Winter, 1982; Teece et al., 1997). Cross-functional development teams also seem to accelerate the development process. However, such processes require continuous communication support for teams that facilitates information flows and makes it easier for team members to understand others’ specialties and to coordinate overlapping development phases (Brown & Eisenhardt, 1995). Better communication helps team identify problems earlier and focus on the customer in the development effort (Nambisan & Wilemon, 2000).

Song and Noh (2006) argue that the use of human resources in cross-functional teams increases functional diversity and the amount and variety of information available to the team members. Moreover, the use of human resources increases team members’ ability to identify, understand, and solve problems by a focus on the customer (Brown & Eisenhardt, 1995; Song & Noh, 2006).
In the literature, successful R&D is seen as the result of the balance among relatively autonomous problem-solving activities coordinated by project teams, the project leaders with their leadership discipline, and strong senior management with its overarching product vision (Brown & Eisenhardt, 1995). This balance creates a fast development process with successful outcomes such as high-quality product concepts. Studies have shown that human resources such as project leaders have a critical effect on process performance, product effectiveness, and good communication between the project team and management (Brown & Eisenhardt, 1995; Clark & Fujimoto, 1991; Thieme, Song, & Shin, 2003). Project leaders are powerful because of their strategic vision and management skills. They are also good at lobbying for project resources and isolating project teams from outside interference (Ancona & Caldwell, 1992).

Studies have also shown that strong project leaders are important human resources because they command a great deal of respect. This respect helps them attract people to the teams and work cooperatively with senior management in shaping overall concepts (Clark & Fujimoto, 1991). Their vision is important, for example, in the creation of product concepts (Song & Noh, 2006). Project leaders also have a role as group managers of small project teams. Committed top managers and middle managers are also important resources because they can influence the kind and amount of resources devoted to projects (Kandemir et al., 2006).

2.2.1.1 Knowledge and Skills of Human Resources
Studies have also addressed the importance of human resources by focusing on the knowledge R&D people have. In general, the research attention has shifted from tangible resources to intangible resources.

Čater and Čater (2009), explain that the reason for the shift in attention is that tangible resources, such as physical resources, generally do not have the attributes of the VRIN framework. Therefore, tangible resources are described as strategic resources. This idea has led to the assumption that intangible resources are more important to the firm than tangible resources as far as competitive advantage (e.g., Hall 1992; Kogut & Zander, 1992; Hitt, Bierman, Shimizu, & Kochhar, 2001; Čater & Čater, 2009). This shift in attention can also been seen in the R&D focus. For example, in such research, a common idea is that intangible resources such as knowledge provide the base that underlies successful R&D (Leonard-Barton, 1992).
People have knowledge (Leonard-Barton, 1992). According to Henard and McFadyen (2012), knowledge workers are responsible for developing new products. Therefore, firms should employ people who can together create a base of R&D knowledge.

Knowledge can be acquired in different ways including, for example, advanced studies. After completing their advanced studies, most people (i.e., professionals) continue to expand their knowledge acquired in formal education through learning by doing in their firms. Hitt et al. (2001, p. 14) state that professionals “bring their explicit knowledge derived from formal education into their firms and build tacit knowledge through experience”. Thus, a firm can create and develop its knowledge base by employing people with relevant education and degrees and by giving them the opportunity to advance their knowledge through work experience.

In R&D, employing qualified people with marketing and technical knowledge increases the probability of successful product developments. Previous studies claim that sustained, above-average returns come from products or processes that create value for the customer through their fit with market demands (Verona, 1999). Cooper (1990) observes that the lack of market orientation and assessment largely explains why firms fail with their R&D efforts. Other R&D researchers claim that it is important that firms understand their business environment and their customers’ demands (e.g., Song & Montoya-Weiss, 1998; Cooper & Kleinschmidt, 1995). Firms must have the capacity to analyse their markets so that they can understand and pursue market opportunities (Brown & Eisenhardt, 1995; Verona, 1999; Kandemir et al., 2006).

To minimise the risk of developing a product or process the market will reject, the literature emphasises that firms must have human resources (i.e., individuals) with appropriate market knowledge involved in the development process (Brown & Eisenhardt, 1995; Fredericks, 2005; Enkel, Perez-Freije, & Gassmann, 2005). For example, Kandemir et al.’s (2006) research on new product development projects in the biochemistry industry shows that detailed market research has a great effect on the project success in the development phase. This means that it is important for individuals to have market knowledge and to keep this knowledge current (Verona, 1999).

Another frequent claim is that the people who are involved in the development process should have the technical and scientific understanding needed to engage in successful product development. Kandemir et al. (2006), who argue that the
development process involves technical activities that are mostly related to product testing, emphasise that most people who perform technical activities are technical experts. According to Sim, Griffin, Price, and Vojak (2007), these experts typically have technical degrees, which means they have been educated in technical areas and have formal technical and scientific knowledge. As Del Canto and González (1999) conclude, people with relevant education, experience, and know-how in R&D activities positively influence the realisation of development processes.

2.2.2 Technical Resources

R&D researchers have a clear interest in human resources and knowledge resources (both of which are intangible R&D resources). However, some research focuses on R&D tangible resources. This research suggests that technical resources are needed to perform R&D activities.

For instance, Kandemir et al. (2006) write that a firm must possess sufficient technical resources to support the work of technical experts in their activities. They describe these technical resources as the resources devoted to such activities as in-house product testing with customers, market testing, and pilot production. Del Canto and González (1999) explored technical resources (e.g., technical equipment, manufacturing facilities, and buildings) and their effect on internal R&D activities at Spanish firms. They stress that in addition to firm size or the scale of the plant the importance of the firm’s fixed assets must be acknowledged. Kandemir et al. and Del Canto and González argue that R&D often requires a minimum prior investment in highly sophisticated technical equipment. Other researchers, such as Mitchell and Zmud (1999), also claim that technical resources such as information technology (IT), production resources, and manufacturing resources influence the product development process positively.

2.2.3 Financial Resources

Other R&D researchers emphasise the importance of financial resources (e.g., Cooper, 1999; Cooper & Kleinschmidt 1995, 2007; Vieites & Calvo, 2011). The claim is that the lack of financial resources may limit the ability of the firm to support its R&D activities (Teece & Pisano, 1994; Helfat, 1997).

Cooper and Kleinschmidt (1995) found that financial resources are important success factors that influence the development process. In their reprinted article
(2007, p. 53), they comment on their earlier findings: “Resources—both people and money—are strongly tied to new product performance”.

Vietes and Calvo (2011) argue that the level of R&D expenditure (i.e., the financial resources) is the most common indicator of a firm’s R&D commitment. They examine how financial resources (as a percentage of annual turnover) and other factors support large, Spanish companies’ R&D activities. They conclude that financial resources and cooperation positively influence R&D activities.

Based on the Transaction-Costs Economics and Agency literature, Del Canto and González (1999) discuss the idea that internal funds are more conducive to R&D investment than external funds. They conclude that internal funds are “preferable to external ones because there probably exist information asymmetries between the firm’s management and external capital markets” (Ibid. p. 895).

2.2.4 Relationships

The research on the RBV has generally not examined the resources obtained by interconnected firms. The explanation is that the RBV focuses on value extracted from resources that are fully owned and controlled by one firm (Dyer & Singh, 1998; Gulati et al., 2000; Lavie, 2006, 2007). In the R&D research, empirical studies reveal that because successful R&D is very much influenced by relationship resources, firms need to manage and develop synergistic relationships with external actors, in particular customers and suppliers.

Research by Lüthje and Herstatt (2004) and Enkel et al. (2005) on successful R&D stress that the integration of customers with the development process enhances the innovation capabilities of firms and reduces the market risk of innovation. Similarly, other studies emphasise the importance of integrating suppliers in product development as a way to reduce costs, improve the quality of purchased materials, speed up product development, and improve access to technology (Ragatz, Handfield, & Scannell, 1997). Studies on R&D show that institutions can support firms by improving their innovation capacity with enhanced interactive learning. Such learning supports and environment that is beneficial to continuous improvement and the creation of product and processes.
2.3 Chapter Summary

This chapter describes the RBV in terms of how firms can achieve competitive advantage and sustainable competitive advantage through the use of their various resources. This section summarises the key points in this chapter.

The RBV considers resources – primarily strategic resources – as the key source of competitive advantage and sustainable competitive advantage. As resources can be classified as tangible or intangible, researchers have suggested different frameworks to examine their strategic relevance. Barney’s (1991) VRIN framework, which is probably the dominant framework, is based on the four resource attributes: Value, Rare, Imperfect Imitability and Non-Substitutability. If resources have these attributes, they are strategic resources.

The chapter reviews the work of R&D researchers who have used and developed the RBV. These researchers agree that a firm’s success with its R&D activities depends on its various resources and capabilities. Resources are categorised as technical, financial, human, knowledge and skills, and relationships. Capabilities are characterised as innovation, marketing, and manufacturing.

A number of studies observe that firms depend on both resources and capabilities. However, fewer studies focus on how resources are managed. Resource Management is an important subject with relevance for the research question of this thesis. Chapter 3 discusses Resource Management.
Chapter 3: MANAGEMENT OF RESOURCES

As discussed in Chapter 2, the RBV claims that firms can achieve competitive advantage and sustainable competitive advantage using their strategic resources. In the RBV, resources are not equally important; the important (and strategic) resources are those that have the VRIN attributes (see Chapter 2).

One area in the R&D literature that has not been extensively researched is the management of resources. In the strategic management research that takes the RBV, this topic is much debated. An intense and enduring debate continues among researchers (e.g., Foss 1998; 2000; Foss & Knudsen, 2003; Priem & Butler, 2001a, 2001b). Truijens (2003) provides an extensive review of this debate. Two issues in the debate are the RBV’s static focus on resources (e.g., Teece et al., 1997) and the neglect of firms’ capacity to exploit resources (Mahoney, 1995), processes, and actions (Whittington, 2002; Johnson et al., 2007, p. 9; Höglund & Sundström, 2011; Höglund, 2013) as sources of competitive advantage.

As early as 1959, Edith Penrose addressed these issues. She was one of the first researchers to suggest that a firm can be viewed as a collection of productive resources. In her theory of the growth of the firm, the focus is on value creation. Researchers still refer to her contributions to modern RBV thinking (e.g., Kor & Mahoney, 2000, 2004; Rugman & Verbeke, 2002; Lockett, Thompson, & Morgenstern, 2009). Penrose’s interest was the production and competitive growth approach that established firms take (Best & Garnsey, 1999; Rugman & Verbeke, 2002; Selegård, 2011). She described the firm as both an administrative organisation and a collection of resources managed so as to generate profit (Penrose, 1959/2009, p. 28).

According to Penrose, a firm’s heterogeneity, which derives from the difference between a firm’s resources and the services rendered by those resources, establishes its unique character. Penrose (1959/2009, p. 22) wrote:
Strictly speaking, it is never resources themselves that are the “inputs” in the production process, but only the services that the resources can render. The services yielded by resources are a function of the way in which they are used – exactly the same resource when used for different purpose or different ways, and in combinations with different types or amounts of other resources provides a different service or a set of services.

Penrose (1959/2009, pp. 41-43) thought that managers have the responsibility to coordinate resources using the firm’s administrative framework. However, she observed that the lack of profitable opportunities limits firm growth (p. 24). Such growth depends on having productive resources as well as the administrative framework for resource coordination (p. 28). Firm managers, therefore, play an important role in the firm because of their experience and capabilities related to the exploitation of resources. Aaker (1989) and Porter (1991), like Penrose, take an external view of how firms can exploit resources to gain competitive advantage. More recently, researchers (e.g., Manhoney & Pandian, 1992) have reminded other researchers of these insights and re-focused attention on resource exploitation.

This chapter presents various perspectives on the management of firms’ resources. The chapter begins with the capability and the dynamic capability perspectives on resource management followed by the Management Control perspective. The chapter next reviews management control in R&D. The chapter concludes with a summary of lessons learned from the research on management control and management control in R&D.

### 3.1 Competitive Advantage through Resource Exploitation

Some researchers suggest that one way to study how firms exploit their resources is to take the capability perspective. The word “capability” is now commonly used in the RBV literature. In the early 1990s, the theme of capability – used to develop the RBV – became popular in strategy management research.

Researchers observed that resources do not mean much in themselves; they need to be exploited in order to be of use (Amit & Schoemaker, 1993). For example, Teece et al. (1997, p. 515) state that the RBV cannot satisfactorily explain how
successful firms demonstrate “timely responsiveness and rapid and flexible product innovation, coupled with management capability to effectively coordinate and redeploy internal and external competences”. Stemming from the idea that firms need to upgrade their rent-generating resources in an on-going process (Mahoney, 1995), the main argument of this research is that resources and capabilities together contribute to competitive strategies. For instance, Grant (1991, p. 119) writes:

But, on their own, few resources are productive. Productive activity requires the cooperation and coordination of teams of resources. A capability is the capacity for a team of resources to perform some task or activity.

Capability refers to a firm’s capacity to exploit its resources. The exploitation is the result of combining resources with the firm’s organisational processes, aimed at a particular goal (Prahalad & Hamel, 1990; Grant, 1991; Amit & Schoemaker, 1993; Helfat & Peteraf, 2003; Akio, 2005). This means that capabilities create a link that permits exploitation of resources (Day, 1994). Researchers who take the capability perspective (e.g., Grant, 1991; Amit & Schoemaker, 1993; Akio, 2005) distinguish between capability and resources.

Capabilities are described as firm-specific, information-based, tangible and intangible processes that develop over time by the interaction among the firm’s resources. Unlike resources, capabilities are embedded in the firm’s organisation framework and processes. Moreover, unlike resources, capabilities refer to the firm’s productive enhancement of its resources (Amit & Schoemaker, 1993).

Dynamic capabilities, unlike mere capabilities, are concerned with change (Winter, 2003). As Mahoney and Pandian (1992) and Makadok (2001) point out, the Schumpeterian perspective (i.e., firm destruction and innovation), codified in the dynamic capability perspective, challenges the Ricardian perspective codified in the RBV perspective (e.g., Amit & Schoemaker, 1993; Dierickx & Cool, 1989; Mahoney, 1995; Nelson & Winter, 1982; Teece et al., 1997).

Researchers who take the dynamic capability perspective argue that the ability to respond to environmental changes is an important firm capacity. The dynamic capability framework is concerned with the firm’s capacity to manage a rapidly changing environment by creating new resources and renewing or altering its resource mix (Teece et al., 1997; Helfat & Peteraf, 2003; Ambrosini & Bowman, 2009). Researchers who take this approach study whether dynamic capabilities
and operate singly, whether and how dynamic capabilities operate in combination and which dynamic capabilities might be more suitable (Ambrosini & Bowman, 2009).

In the dynamic capability perspective, at least two descriptions of the term “dynamic capabilities” are offered. Teece et al. (1997, p. 516) describe dynamic capabilities as “the firm’s ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments” Eisenhardt and Martin (2000, p. 1106) describe dynamic capabilities as “strategic and organizational processes like product development, alliancing, and strategic decision making that create value for firms within dynamic markets by manipulating resources into new-value creating strategies”.

In a discussion of dynamic capabilities, Winter (2003, p. 991) refers to “those that operate to extend, modify or create ordinary capabilities”. In comments on the various descriptions of capabilities, Ambrosini and Bowman (2009) conclude capabilities are a general process at firms while dynamic capabilities change the international resources of the firm. Dynamic capabilities can integrate resources, reconfigure old resources, and create new resources.

In sum, dynamic capabilities reflect a firm’s ability to gain a new form of competitive advantage given its path dependencies and market position (Leonard-Barton, 1992; Teece et al., 1997). Because dynamic capabilities focus on a firm’s ability to manage change (Winter, 2003), they are important, for example, in technology-intensive industries where turbulence and innovation are the norm.

Barney (1995, p. 56) links the RBV debate and its static focus on resources to the capabilities perspectives when he writes: “A firm's competitive advantage potential depends on the value, rareness, and imitability of its resources and capabilities.” In 1995, Barney introduced the VRIO framework, which some consider an improvement on his 1991 VRIN framework (see Chapter 2). In the VRIO framework, the firm attributes needed for sustainable competitive advantage are Value, Rare, Imperfect imitability and Organised. According to the VRIO framework, only the resources or capabilities that have these attributes can lead to sustainable competitive advantage for the firm. In contrast to the VRIN framework, the VRIO framework emphasises the importance of resource exploitation. For firms, the question is the following: Is the firm organised to exploit the full competitive potential of its resources and capabilities?
Barney and Mackey (2005, p. 10) explain that the question of organisation includes all the components needed for implementing strategies. They conclude that while the components are, in principle, inimitable, they are important if a firm is to gain competitive advantage. Barney and his various co-authors find that proper resource exploitation is effected using the firm’s organisational components such as management control, organisation structure, and compensation polices (e.g., Barney, 1995; Barney & Mackey 2005, p. 10; Barney & Clark, 2007, p. 67; Barney & Hesterly, 2008, p. 90). According to Barney (1995), and Barney and Clark, (2007), these components are the so-called “complementary resources” because, in themselves, they are not sources of competitive advantage.

3.1.1 Management Control
Different ideas are advanced in the management control literature on how firms should manage firm resources strategically so as to achieve their desired objectives. The roots of this literature are in System Theory, Contingency Theory, and Anthropological Theory (Berry, Broadbent, & Otley, 1995; Collier, 2005).

“Management” in this literature is often described in terms of organising strategic resources and of directing goal-oriented activities (Anthony, 1965, pp. 15-18; Nilsson, Olve, & Parment, 2010, pp. 48-49; Simons, Dávila, & Kaplan 2000, p. 4; Jannesson & Skoog, 2013, p. 7). “Control”, however, is described as any process managers use to organise resources, direct attention, and motivate organisational members to act in appropriate and desired ways that will achieve the firm’s objectives (e.g., Eisenhardt, 1985; Ouchi, 1977; Govindarajan & Gupta, 1985; Cardinal, 2001).

“Control”, which is said to originate in organisation research, began to interest organisation researchers in the late 1970 and early 1980s following publications by March and Simon (1958), Burns and Stalker, (1961), Thompson (1967), Lawrence and Lorsch, (1967), Child (1973), Galbraith (1973), and Mintzberg (1978, 1983). For example, organisational researchers such as Burns and Stalker and Lawrence and Lorsch have shown that the choice of organisation structure and controls affects the ability of the organisation to react to environmental changes.

Lawrence and Lorsch (1967) studied how firms in various industries differentiate and integrate their structures in order to fit their industry environments. This research led to Contingency Theory. According to Lawrence and Lorsch, while differentiation concerns differences in orientation and structure, integration concerns the state of the inter-collaboration among departments (pp. 10-11). They
found that firms in unstable environments were more effective if their structures were organic, less formal, and decentralised. They also found that firms in stable environments were more effective if their structures were mechanical, more formal, and centralised. Yet another finding was that large firms in unstable environments were more effective if their structures allowed for more differentiation and mutual adjustments among departments. In more stable environments, firms rely on the integration among departments.

As organisations grow in size, they became more complex. This means that more control is needed (Jannesson & Skoog, 2013, p. 6). Today both academics and practitioners generally consider organisation control very important (Chenhall, 2003; Carenys, 2012). Management concepts in the area of management control draw on ideas from the economic theory of the firm. The core of this theory, which explains why firms exist, is that a firm is directed by ‘homo economicus’, the so-called rational person who pursues profit maximisation or cost minimisation (Whittington, 2002, p. 22). The theory posits that the main objective of profit maximisation means that a firm produces outputs to the point where marginal cost (MC) equals marginal revenue (MR). If the cost incurred is too high, the firm will cease producing outputs. This means that the literature traditionally views managers as profit-oriented individuals who use different control mechanisms to exploit resources effectively, to follow strategies, and to achieve desired objectives by influencing other organisation members to act in appropriate and desired ways (Collier, 2005; Dahlgren & Söderlund, 2013, p. 43).

Management control researchers tend to discuss firms’ control mechanisms in terms of various control systems. Carenys (2012, p. 1) explains:

> The earliest studies conducted on control systems saw them as cybernetic and formal systems, focused on the use of financial and accounting information systems, fundamentally through cost accounting and budgets.

As the area of management control developed, it was enriched by psychosocial and cultural perspectives. Human relationships, leadership, motivation, the environment, and culture are now featured in the management control literature (e.g., Berry et al., 1995 pp. 21-25; Lindvall, 2001). Today, management control is viewed as a rather open, social system as opposed to the previous closed, mechanical system (e.g., Carenys, 2012). Management control, which is today broader, more strategic, and more outward-looking, considers both financial and
non-financial elements in the study of how organisations achieve their goals (Jannesson & Skoog, 2013, p. 8).

There are numerous definitions and descriptions of management control (e.g., Anthony, 1965; Lowe & McInnes, 1971; Chenhall, 2003). Researchers tend to distinguish between formal and informal management controls. Some researchers are interested only in formal controls while others are interested in both formal and informal controls (e.g., Abernethy & Stoelwinder, 1994; Rockness & Shields, 1984). Formalisation, or standardisation, refers to the extent work is defined and regulated (Hatch, 1997). Formal control (or direct control) is managed by written documentation from management that can influence/regulate employees’ actions and behaviours as well as support pre-defined goals (e.g. plans, budgets, regulations, and quotas; Jaworski, 1988). Informal control (or indirect control) is exercised by unwritten norms/culture that typically originate with the employees.

Robert Anthony (1965) is usually recognised as the first researcher to describe management control. He divided the world of control among strategic planning, management control, and operational control (pp. 15-18). Inspired by System Theory, Anthony defined strategic planning as follows:

The process of deciding on objectives of the organization, on changes in these objectives, on the resources used to attain these objectives, and on the policies that are to govern the acquisition, use, and disposition of these resources. (p. 16)

Anthony defined management control as follows:

The process by which managers assure that resources are obtained and used effectively and efficiently in the accomplishment of the organization’s objectives. (p. 17)

This definition, Anthony claimed, which combines planning and control, describes operational control as the “process of assuring that specific tasks are carried out effectively and efficiently” (p.18). Langfield-Smith (1997) and Otley (1999) claim that Anthony’s definition of management control is problematic because it suggests a disconnection among strategic planning, management control, and operational control. According to Ferreira and Otley (2009), Anthony’s definition encourages a narrow view of management control in which formal controls are examined without consider of their environments. Cleary inspired
by Contingency Theory, Emmanuel, Otley, and Merchant (1990) and Otley (1994) note that an organisation exists in a dynamic environment. Therefore, management control should be viewed more broadly with change taken into consideration.

Otley (1994) emphasises that while management control has elements of strategic planning and operational control, it should also reflect the fact that managers must continually reformulate strategies as the environment changes. Thus, Otley supports Lowe’s (1971) broader definition of management control. Lowe defines management control as follows:

A system of organizational information seeking and gathering, accountability, and feedback designed to ensure that the enterprise adapts to changes in its substantial environment and that the work behaviour of its employees is measured by reference to a set of operational sub-goals (which conform with overall objectives) so that the discrepancy between the two can be reconciled and corrected for. (p. 5)

Lowe’s (1971) definition refers to strategic issues as the interaction of the organisation and its environment, and to operational issues as the effective implementation of its strategic plans (see also Kloot, 1997). More recently Chenhall (2003, p. 129) proposed an even broader definition of management control: “The systemic use of management accounting to achieve some goals.” This definition encompasses management accounting and other controls such as personal or cultural controls.

Ferriera and Otley (2009) also argue for a broader definition of management control that includes the entire strategic process – both strategy formulation and strategic implementation. They use the term Performance Management System to summarise these more general processes that include “formal mechanisms, processes, systems, and networks used by organizations, and […] informal controls […]” (p. 264).

Simons (1994, 1995), who takes a narrower view of management control than Chenhall (2003), suggests that effective control should encompass the freedom that allows organisations to innovate and achieve pre-defined objects. Management control is not simply the procedures and assurances related to how individuals work productively to achieve goals. Simons defines management control as
“formal, information-based routines and procedures used by managers to maintain or alter patterns in organisational activities” (1994, p. 171). [Emphasis in the original] His definition includes planning systems and monitoring systems based on information use (see also Henri, 2006) and excludes the narrow view of information-based routines.

There are similarities between Simons (1995) and Anthony (1965) in their focus on management control. Both authors see formal routines as methods for preserving and changing activities in the organisation. However, they disagree on their views on strategy. Simons thinks that management control is relevant for formulated strategies (see also Ferriera & Otley, 2009) and for re-formulation of strategies. This perspective means that Simons permits double-directed communication (Johanson & Skoog, 2007, p. 26).

3.1.2 Different Types of Control

Researchers have identified different types of controls, including behaviour control (also referred to as bureaucratic, structural, or process control; Blau and Scott, 1962/2003), market control (Ouchi, 1979), cultural control (Arvey, 1979), output control (Ouchi, 1977, 1979), and input control (Merchant, 1985; Mintzberg, 1983).

Some of the management control research relates to performance measurements (Henri, 2004). Originally, this research was mainly based in financial measures and was linked to the planning and control cycle (Ibid.) However, Kaplan and Norton (1992) created a performance measurement framework intended to supplement traditional financial measurements with the addition of strategic, non-financial performance measures. Their Balanced Scorecard assumes the organisation should be viewed from four perspectives: the Financial Perspective, the Customer Perspective, the Internal Business Perspective, and the Innovation and Learning Perspective. The three non-financial perspectives allow firms to track their non-financial progress and, at the same time, improve the management of their intangible assets that are sources of future growth (Kaplan, 2008).

Focusing instead on strategic renewal, Simons (1990, 1991, 1994) has promoted a framework for strategic control that consists of four interrelated control systems (i.e., Levers of Control). He derives his framework, which is an extended control typology, from his research findings. The Levers of Control (LOC) framework is based in multiple definitions of strategies and emergent aspects of strategy development (Simons, 1995).
The LOC framework reflects the tension between innovation and control in firms. According to Simons (1990, 1991, 1994), senior managers use different control systems depending on the decision context. These control systems can be used to monitor and evaluate performance or to facilitate learning interactively. Simons argues that, for senior managers, these control systems act as positive and negative forces that create a balance between the promotion of innovation and the achievement of pre-defined goals.

The LOC framework focuses on formal routines and procedures as well as on informal systems such as norms and socialisation. As Henri (2006), observes, this means that Simons includes planning systems and monitoring systems based on information use. The LOC framework is associated with the following four concepts: Core Values, Risks to be avoided, Critical Performance Variables, and Strategic Uncertainties. Special control systems are Belief Systems, Boundary Systems, Interactive Control Systems, and Diagnostic Control Systems. See Figure 3.

![Diagram of LOC framework]

Figure 3: Modified figure based on Simons's LOC framework (Simons, 1994, p. 173)
Belief Systems control the organisation by focusing on its intended goals, missions, and core values (see Jeanson & Sundström, 2014). Simons (1995, p. 34) describes Belief Systems as “the explicit set of organizational definitions that senior managers communicate formally and reinforce systematically to provide basic values, purpose, and direction for the organizations”. Thus, Belief Systems use formal documents (e.g., credos, mission statements, and statements of purpose) and informal communications (e.g., team and other social activities) (Simons, 1994). Belief Systems inspire the search for new opportunities and discoveries at the organisation with the goal of promoting collective knowledge (Simons, 1995, pp. 33-34).

While Belief Systems are thought of as positive, Boundary Systems are thought of as negative because they restrain the opportunity searches that Belief Systems promote (Jeanson & Sundström, 2014). Boundary Systems, which are ‘the brakes’ of the organisation, are formal systems that senior managers use “to establish explicit limits and rules which must be respected” (Simons, 1994, p. 170). Boundary Systems control the Risks to be avoided by setting limits on strategically undesirable behaviour. Simons (1994, 1995) states that Boundary Systems are negative systems because they define acceptable organisation behaviour in employee codes of conduct and planning and operating directives, all of which are written/enforced by managers.

Diagnostic Control Systems are used to communicate and control the performance and progress of the organisation (Simons, 1994, 1995, p. 59). These systems are “the formal feedback systems used to monitor organizational outcomes and correct deviations from pre-set standards of performance” (Simons, 1994, p. 170). Diagnostic Control Systems include business plans, budgets, and cost accounting systems that track differences between pre-set goals and results. Thus, Diagnostic Control Systems provide senior managers with information on organisation performance (i.e., feedback), goal-setting, and goal achievement (Jeanson & Sundström, 2014). It is of interest that Diagnostic Control Systems use historical data for comparisons so that organisation progress can be monitored and achievements can be recognised (Simons, 1995).

Interactive Control Systems are formal system that senior managers use “to regularly and personally involve themselves in the decision activities of subordinates” (Simons, 1994, p. 171). These systems aim to provide feedback and information useful for evaluation and redirection of strategy. Examples of such information are competitive analyses and market feedback reports (Simons, 1995, p. 96). In this way, Interactive Control Systems monitor the Strategic Uncertainties
and lead to new, strategic responses to changing environments. Simons (1994) observes that any diagnostic system can be made interactive if senior managers pay it continuing and frequent attention According to Simons (1994), the design of Interactive Control Systems is influenced by dialogue, organisational learning, and analyses of Strategic Uncertainties.

Belief Systems and Interactive Control Systems are intended to encourage organisational opportunity seeking and innovation. Boundary Systems and Diagnostic Control Systems are intended to ensure that organisation members follow rules and codes (Simons, 1994, 1995; Toumela, 2005).

Management control researchers point to several strengths of Simons’s LOC framework. First, the LOC framework highlights strategic issues and implications for the control system (Ferreira & Otley, 2009). Second, the LOC framework gives us a better understanding of the design of management control systems because of its focus on their specific uses (Ibid.). Third, the LOC framework has general application because it involves a range of controls that firms use (Ibid.).

However, there are also critics of Simons’s LOC framework. According to Collier (2005), Simons did not attempt to include informal controls or other control mechanisms such as group norms, socialisation, and culture in his Belief Systems. According to Berry et al. (1995), because Simons’s LOC framework was developed at the senior management level, some management control researchers ask if the framework applies only to that level.

Otley (1999) developed the Performance Management Systems (PMS) framework for analysing management control. This framework is structured around five issues related to objectives and strategies in addition to plans for their attainment, target-setting, incentive and reward structures, and information feedback loops. According to Ferreira and Otley (2009), there is at least one common feature between Simon’s LOC framework and Otley’s PMS framework. Strategy is the key feature of both frameworks. Moreover, Simons’s Belief Systems and Boundary Systems influence Otley’s performance measures.

More recently, Ferreira and Otley (2009) developed a newer performance management control framework derived inductively from their case study research. Their framework, which consists of 12 questions, integrates Otley’s PMS framework with Simons’s LOC framework. Ferreira and Otley write that their framework has similarities with both Diagnostic Control Systems and Interactive Control Systems because it uses performance measures. They also emphasise that the
issues of target setting and of rewards derive essentially from Simons’s Diagnostic Control Systems while information flow is embedded in the LOC framework. The 12 questions in Ferreira and Otley’s framework are broad enough to help researchers who are interested in studying integrated performance and management. However, Collier (2005) has raised some issues concerning the framework’s focus on formal system design rather than on systems in use.

Malmi and Brown (2008) constructed a control typology for management control systems. They are critical of management control research because it has “considered single themes or practices that are seemingly unconnected from each other and the context which they operate[...]” (p. 287). With reference to Abernethy and Chua (1996), Alvesson and Kärreman (2004), Flamholtz, Das, and Tsui (1985), Otley (1980), and Simons (1995), Malmi and Brown note that organisations have a number of controls. They write that these controls can “be more traditional accounting controls such as budgets and financial measures or administrative controls such as organisational structure and governance systems, along with more socially based controls such as value and culture” (p. 287).

Malmi and Brown’s (2008) typology includes Planning, Cybernetic Controls, Rewards and Compensation, and Administrative Controls. They describe the planning and controls for the functional areas of the organisation that direct efforts and behaviour. They highlight two types of planning: action planning in which goals and actions are decided in advance for a 12-month period, and long-range planning, which has a more strategic focus because goals and action are envision a longer time perspective.

Malmi and Brown (2008) describe Cybernetic Controls (i.e., Budgets, Financial Measurement Systems, Non-financial Measurement Systems, and Hybrid Measurement Systems). Like the Balanced Scorecard, the last control has both financial- and non-financial components. They follow Green and Welsh’s (1988) definition of cybernetic control:

[…] a process in which a feedback loop is represented by using standards of performance, measuring system performance, comparing that performance to standards, feeding back information about unwanted variance in the systems, and modifying the system’s component. (p. 289)

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3 The five issues are Vision and Mission, Key Success Factors, Organisational Structure, Strategy, and Plans. Key performance measures are target setting, performance evaluation, reward systems, information flow, systems, and networks,
The Rewards and Compensation control focuses on motivating individuals and groups to improve their performance by attaching rewards to effort direction, effort duration, and effort intensity (Malmi & Brown, 2008). In this typology, Rewards and Compensations is a separate control mechanism even if it is common to link Rewards to Cybernetic Controls. Administrative Controls (e.g., firms’ organisation design and structure, governance structure, and procedures and policies) involve directing the behaviour of employees by organising individuals and groups, monitoring their behaviour, and holding them accountable for their behaviour. Administrative Controls also involve the specification of how tasks are to be performed.

3.2 Research on Management Control in R&D

In the R&D literature, R&D is described as a process of non-repetitive, often unstructured activities that managers administer. Because the process requires employee creativity, human resources are an essential element of R&D. Creative ideas lead to innovative, successful R&D results (e.g., Amabile et al., 1996; Burbiel, 2009; Lund, 2012).

An area of discussion in R&D literature is creativity. The discussion focuses on how managers identify creative human resources (i.e., the psychological aspects) and on how managers create R&D settings that nurture the creative spirit in their human resources (i.e., the employees). Various suggestions are offered: encouraging and supporting employees’ ideas, giving employees work flexibility and freedom, providing employees with sufficient resources and time for problem-solving, and minimising formal, bureaucratic procedures.

R&D researchers who study creative thinking and innovation have examined the management control of R&D activities. They are concerned that management control may conflict with practice when hierarchical organisations, with their many rules, regulations, and restrictions on employee autonomy, discourage creative thinking and creative behaviour (e.g., Amabile et al., 1996; Amabile, 1998; Andriopoulos, 2001).

Interest in the topic of R&D research and management control has increased over the years. Kerssens-van Drongelen and Bilderbeek (1999, p. 36) writes that this interest is reflected in “articles having titles and abstracts featuring words such as effectiveness, performance, success, control, monitoring, assessment, measurement, bench-marketing, auditing and evaluation”. One main conclusion
in these articles is that R&D is a very worthwhile investment that contributes to the competitiveness of firms (Davila, 2000; Cardinal, 2001; Cedergren, 2011). Yet the literature recognizes that management control of R&D is extremely challenging.

3.2.1 Organising for R&D

The research on R&D shows that well-managed R&D depends, among things, on excellent internal organisation (Brown & Eisenhardt, 1995). A number of researchers have studied how R&D is best managed.

Although organisation researchers have shown that the choice of organisation structure influences firm success (Burns & Stalker, 1961; Woodward, 1965), most management control researchers treat organisation structure as a contingency variable and not as a control mechanism (e.g., Ouchi, 1977). Studies of R&D management control conclude organisation structure should be aligned with the management control systems (Simons et al., 2000, p. 38).

Organisation structure can be described as the formal arrangements used to distinguish between power and authority, roles and responsibilities, and rights and duties. Organisation structure also deals with systems for communicating information internally (Woodward, 1965, pp. 17-18; Mintzberg, 1983, pp. 19-23). In short, organisation structure specifies how work is to be performed in alignment with firm strategy.

Researchers interested in organisation structure as it relates to R&D draw on the literature and theories on organisations. They study the advantages and disadvantages of different organisation structures as far as firms’ R&D strategies, activities, and innovation capacities.

According to Allen (2001), R&D was one of the first business areas to employ large numbers of highly educated and specialised human resources (i.e., personnel). He explains that R&D requires more such people than other business areas. Researchers as well as practitioners search for new ways to structure R&D activities with the aim of increasing firm efficiency and effectiveness.

Researchers such as Galbraith (1971), Clark and Wheelwright (1992) Allen (2001), and Ulrich and Eppinger (2008, p. 25) show that R&D can be structured by grouping human resources by functions, products, or projects, or by functions and products in the so-called matrix organisation. In the functional organisation,
its human resources are grouped into different functions such as R&D, procurement, production, or sales (e.g., Mintzberg, 1983, p. 58). This means that in the functional organisation, a group of people report to a supervisor or manager in each area of specialisation. Such an organisation structure, which facilitates the centralisation of functions, is associated with economies of scale. Therefore, the literature views the functional organisation structure as appropriate at firms that produce products in high volume.

The functional organisation structure also fosters the development and spread of specialisations and deep expertise among the human resources (Mintzberg, 1983, pp. 58-59; Allen, 2001; Ulrich & Eppinger, 2008, p. 29). Individuals, grouped by function, perform the same tasks and use the same skills and resources. Therefore, they learn from each other and gradually become experts in specific functional areas. The literature also emphasises the managerial simplicity and effectiveness of the functional organisation structure that allows managers to control activities more easily (Allen, 2001).

According to the literature, the principal disadvantage of the functional organisation structure is that employee specialisation may create coordination problems owing to delays and bureaucratic red tape. Organisations structured by function may also inhibit renewals of a cross-functional nature (i.e., renewals that require collaboration among and between groups). See Mintzberg, 1983; Allen, 2001; Ulrich & Eppinger, 2008.

Historically, according to Allen (2001), the R&D organisation was structured as a functional organisation in which the functions were based on technology or technological knowledge. This situation changed because of the need to combine different learning and expertise in the development of products. Allen writes: (2001, p. 5); “Products are seldom based upon single disciplines or specialties. It normally requires a blending or integration of knowledge from different specialties to develop even relatively simple products.”

In some organisations, groups of human resources or other resources are organised around a specific market focus (Mintzberg, 1983, p. 60). For instance, product organisation refers to a divisional structure in which products (i.e., goods and services) are grouped on the basis of their similarities and differences. Firms that want to take advantage of their multiple product lines often choose this organisation structure. In the product-based organisation structure, project managers are assigned to products; this structure facilitates cross-functional effects. According to Mintzberg (1983, pp. 60-61), the disadvantage of this market focus is
that product structure demands a large supply of resources (e.g., managers and administrators).

More recent R&D studies conclude it is appropriate for R&D organisations with complex products and processes to adopt an organisation structure that is decentralised, flexible and with significant employee autonomy. Such a structure encourages learning and creativity (e.g., Sundström & Zika-Viktorsson, 2009). There is widespread acceptance among the researchers who have addressed this idea that R&D organisation should be cross-functional and teams should conduct R&D in projects (Brown & Eisenhardt, 1995; Nambisan & Wilemon, 2000; Song & Noh, 2006).

Ford and Randolph (1992) observe that some terms used in this context – for example, matrix-management, project management, matrix-organisation, and project organisation – are interchangeable. They think all these terms refer to the same type of cross-functional organisation that aims to bring people together from different functions to perform tasks on either a temporary or a permanent basis.

A matrix organisation is an organisation structure in which the functional structures and divisional structures are combined and prioritised at the same time (Galbraith, 1971; Allen, 2001; Ulrich & Eppinger, 2008 p. 26; Engwall et al., 2014, p. 62). The matrix organisation is a hybrid that was developed to address the disadvantages of the two structures. While the vertical hierarchy is a traditional function, the horizontal hierarchy consists of, for example, products, projects, or business areas (Ford & Randolph, 1992). One particular strength of the matrix organisation is that it allows the firm to use project teams to complete different tasks.

Project teams, the so-called cross-functional teams, are composed of human resources from different functions and with diverse specialities and knowledge. Project team members work together to solve complex problems and to achieve certain goals. Because the activities in the matrix organisation are grouped in two ways (vertically by function and horizontally by products, projects, and area), project team members have two bosses (Galbraith, 1971; Allen, 2001). They report to the head of a function and to the product manager. Thus, the matrix organisation has dual lines of authority, responsibility, and accountability (Engwall et al., 2014, p. 62).
The R&D literature emphasises that the use of the matrix organisation structure promotes innovation by encouraging communication between people with different specialities and knowledge. Another advantage is that the matrix organisation structure allows the firm to move specialists between different products. In this way, the organisation best uses their highly educated and specialised personnel. The disadvantage of the matrix organisation structure mainly relates to the internal confusion resulting from the two-manager supervision (Galbraith, 1971; Allen, 2001; Engwall et al., 2014, p. 63). Such dual supervision may create conflicts, misunderstandings, and miscommunications.

A project can be described as any activity with a defined set of resources and goals and with a specific time frame. Project organisations, developed to meet contingency requirements, can handle the complexities in their environments by responding to managers’ demands for special and flexible arrangements (Allen, 2001). This organisation structure, which is more direct, has an operational character. Project organisations use project groups with relatively well-defined tasks that are coordinated by projects. These project groups are responsible for the planning, execution, and evaluations of projects within time and financial frames (Galbraith, 1971). Project organisations are recognized for their optimal allocation of project resources and project teams, and for their speedy evaluation of technical and market trade-offs. Thus, project organisations tend to increase the speed and effectiveness of the coordination among different functions (Allen, 2001).

Ford and Randolph (1992) explain that a firm’s organisation structure evolves over time. At first, the structure may take a functional form. However, when the firm finds itself in a complex and dynamic environment, requiring more flexibility, it may change to project organisation. While the functional hierarchy is retained, project management is added as an overlay. According to Ford and Randolph, some organisations make this overlay permanent but still retain the functional hierarchy as the primary structure. When a balance of authority is created between the functional organisation and the project organisation, the firm becomes a matrix organisation.

3.2.2 Managing and Controlling R&D

R&D is typically conducted in projects. The literature is concerned with the management and control of important R&D resources in such projects. Some researchers (e.g., Cooper, 1999; Tatikonda & Rosenthal, 2000) and practitioners
(e.g., the Swedish Project Management Institute) emphasise the importance of, and necessity for, proper management and control of R&D projects.

Management and control of R&D projects, as it exists in today’s firms, originated in the U.S. military (Karrbom Gustavsson, & Hallin, 2014). Although some R&D researchers study general project management and control (e.g., Packendorff, 1995; Söderlund, 2004), many researchers focus more narrowly on intra-projects control. Research on R&D project management generally has two streams: project planning and project execution (Tatikonda & Rosenthal, 2000).

Project planning is based in the idea that because the outcome, for example, of a product or process, is unknown, uncertainty characterises the start of the project (Song, Lee, Lee, & Chung, 2007). Therefore, it is common for researchers to describe project planning as the Fuzzy Front End (Tatikonda & Rosenthal, 2000; Börjesson, Dahlsten, & Williander, 2006; Song et al., 2007). Project planning at the start of a project (e.g., choosing the project, setting measurable objectives, and identifying deliverables) is “the period between when an opportunity is first considered and when an idea is judged ready for development” (Song et al., 2007, p. 232).

Project execution refers to the conduct and completion of the project. Usually the project has a specified time frame and a limited amount of resources. The management literature on project execution focuses on technical performance, costs, and time-to-market. Researchers refer to various structured managerial processes or systems. The most popular systems are phase-gate and stage-gate systems (Tatikonda & Rosenthal, 2000; Cooper, 2008).

Cooper (2008, p. 214) describes the stage-gate system as:

[…] a conceptual and operational map for moving new product projects from idea to launch and beyond – a blueprint for managing the new product development (NPD) process to improve effectiveness and efficiency.

Thus, the stage-gate system is based on the premise that product development is a process. The process is usually divided into a pre-determined set of stages that are composed of a group of prescribed, related, and often parallel activities (Cooper, 1990).
A standard stage-gate model, which is designed for major product development (Cooper, 2008), often has four to seven stages and gates although the exact numbers depend on the firm or division (Cooper, 1990). The entry to each stage is through a gate that controls a development process; such gates may be quality control checkpoints. The gates are crucial in this process because they control risk (Schmidt, Sarangee, & Montoya, 2009). The gates have a set of deliverables or inputs, a set of exit criteria, and an output (Cooper, 1990, 2008). The project leader and project team bring the deliverables (i.e., the inputs) to the gate. The deliverables are the results of the completed activities from the previous stage.

The exit criteria are used in the evaluation of the projects as they pass through the various gates to the next stages. These criteria are questions or checklists designed to reject deficient projects. The outputs are the decisions made at the gates (Go, Kill, Hold, or Recycle) that control the action plans at the next stage (Cooper, 1990, 2008). In short, the exit criteria determine if different tasks have been completed efficiently and effectively and if projects have strong commercial potential (Boulding, Morgan, & Staelin, 1997; Hart, Hultink, Tzokas, & Commandeur, 2003).

Hence, the main function of the gates is to identify the weaker projects so that effort and resources can be devoted to stronger projects. The gates have a broad strategic purpose by facilitating project prioritization and resource allocation in product portfolio management (Cooper, 2008). The review team, whose responsibility is to sort out projects, is usually cross-disciplinary, comprising senior managers from marketing, finance, research and development, and manufacturing (Schmidt et al., 2009). The gates reflect review decisions with high-stakes in which managers bet on product development projects with the greatest potential payoff (Schmidt et al., 2004, p. 339).

The stage-gate system was not intended as a project control mechanism. Cooper (2008, p. 216), who created the term Stage Gate in the 1990s, writes:

Stage-Gate is not, and never was, intended to be a control mechanism [Emphasis in the original] so that executives, auditors, and financial people could control, or worse yet micromanage, projects from their lofty offices. Rather, Stage-Gate is a playbook designed to enable project teams and team leaders to get resources for their projects and then to speed them to market using the best possible methods to ensure success.
Cooper also observes that the stage-gate system should not be a substitute for project management. Rather, the stage-gate system and project management should be coordinated.

3.2.2.1 Measuring R&D
Many R&D researchers study how to measure R&D successes and failures in connection with the performance measurement systems. Performance measurements can be described as quantitative indicators that illustrate how well a firm achieves its objectives. Simons et al. (2000, p. 57) states that performance measurements allow management to move from intuitions to “analysis based on hard data and facts.” They further explain that resource inputs are processed and converted to outcomes. To ensure that the inputs are suitable, that the transformations are efficient, and the outcomes meet specifications, managers can use both financial and non-financial measures to evaluate inputs, the transformations, and the outcomes (Simons et al., 2000., p. 60).


Godenor and Söderquist (2004, p. 193) state that Financial Performance Measurements (e.g., profit goals, margins) focus on “quantitatively measured return on R&D investment”. Financial resources used in R&D should be spent cautiously and only used to maximise outcomes. Some research suggests such maximisation is accomplished by appropriate resource allocation, identification, and selection of promising projects, and cancellation of projects.

The Customer Satisfaction Performance Measurements takes a customer view with the customer at the forefront. These measurements evaluate good performance as exceeding, or at minimum satisfying, customer expectations. The Process Performance Measurements take a managerial perspective, which means that good performance optimises quality, cost, time, and lead-time. Studies that take this perspective emphasise evaluating project progression by goals (Clark & Fujimoto, 1991; Wheelwright & Clark, 1992; Cedergren, 2011, p. 48).
Innovation Performance Measurements (e.g., patents) take a creative, innovative perspective. They define performance as “the successful transformation of research efforts into new products, and as the creative application and combination of new or existing knowledge into new products” (Godener & Söderquist, 2004, p. 193).

Cedergren (2011, p. 3) identifies performance measures such as R&D expenditures as a percentage of sales or numbers of R&D personnel. Among practitioners, these are the most commonly-used R&D performance measures. Cedergren states that because R&D expenditures differ by industry, the percentages of sales measure is useful as a comparison measure of their effectiveness and efficiency among firms in the same industry.

It is widely recognized that R&D investment involves considerable risk-taking (e.g., Wheelwright & Clark, 1995; Dahlgren & Söderlund, 2013, p. 40). As it is difficult to evaluate R&D ideas in advance, R&D spending is a very important issue. Hartmann, Myers, and Rosenbloom (2006, p. 25) write:

R&D spending is a material component of costs and a strategic element of investments, representing from five to ten (or more) per cent of revenues in technology-intensive industries […]. Deciding how much to spend on research and product development is one of the most important recurring strategic choices facing managers of technology-based firms.

R&D spending is often viewed as an expense rather than an investment. According to Hartmann et al. (2006), this is the result of accounting rules that require that R&D expenditures be expensed in the year they are incurred. In reality, R&D expenditures are long-term investments that should be capitalised as assets.

The research on R&D performance measurements typically focuses on the diagnostic systems that are the backbone of the traditional management control systems designed to measure and monitor outcomes. Such systems intend to control that objectives are met through corrective action when deviations from pre-set performance are detected (Godener & Söderquist, 2004; McCarthy et al., 2011; Chiesa & Frattini, 2007). Cedergren (2011, p. 47) concludes that the research on R&D performance management is still at an early stage although the Balanced Scorecard (a widely approved control mechanism) has gained widespread acceptance by practitioners.
Some researchers argue that R&D management control should be discussed in a more holistic way. For example, Simons (1994, 1995) claims that the key task for many managers in R&D organisations is the search for a reasonable balance between control, on the one hand, and the promotion of innovation, on the other. Simons supports the idea that the appropriate combination of Belief, Boundary, Diagnostic, and Interactive Control Systems will help managers balance their need for innovation with the various constraints. Henri (2006, p. 533) says the essence of Simons’s LOC framework is “to manage the inherent organizational tension between creative innovation and predicable goal achievement”.

Various studies on R&D management control use the LOC framework or elements of the LOC framework (e.g., Bonner, Ruekert, & Walker, 2002; Bisbe & Otley, 2004). Although the number of studies using the Belief, Boundary, Diagnostic, and Interactive Control Systems has increased, McCarthy et al. (2011) and McCarthy and Gordon (2011) claim few studies explore these four control systems. McCarthy et al. (2011, p.2) state:

Very few empirical studies have focused on belief, boundary and interactive control systems and seemingly no study has sought to examine how the full spectrum of management control jointly works to influence the performance or outcome of R&D organizations.

3.3 Chapter Summary

This chapter reviews how previous research has examined resource management and control. Researchers who take RBV claim that firms depend on their resources and their capacities to exploit these resources in order achieve competitive advantage and competitive sustainable advantage. Firms exploit such researches using various management control measurements. RBV researchers describe management control as a complementary resource rather than a strategically relevant resource

Some organisation research describes management control systems as open systems composed of a set of control mechanisms. Managers, who are responsible for organising resources, following strategies, and achieving desired objectives, use these control mechanisms. Management control systems thus help managers by focusing employee/firm attention and by promoting and encouraging individual/group action at the firm. Various researchers have proposed frameworks
for the analysis of management control systems. These frameworks include the Balanced Scorecard, Levers of Control, and Performance Management Systems.

Because R&D is an unstructured, creative process, R&D researchers have emphasize the importance management control systems design at R&D organisations. In its review of the literature, this chapter shows that many studies on R&D management control focus primarily on performance measurements. Fewer R&D management studies explore R&D management control from broader perspectives.

Chapter 3 (and Chapter 2) help us understand the conditions R&D firms require so that they can effectively and efficiently exploit their strategic and complementary resources as they seek to achieve and maintain an advantage over their competitors. Chapter 4 proposes an Analytical Framework for this purpose.
Chapter 4: ANALYTICAL FRAMEWORK

This chapter presents an Analytical Framework based on the main concepts presented in Chapters 2 and 3. The Analytical Framework integrates the RBV and the Management Control models for use in the empirical analysis of firm performance and competitive advantage.

The success of R&D firms depends on their available resources and how these resources are exploited in ways intended to achieve their R&D objectives. The assumption is that R&D performance is a factor in how competitive firms are in their market and their industry. This study views the ability of R&D firms to respond to threats from their competitors as the result of their performance that, in turn, depends on their strategically relevant resources and their capabilities for exploiting those resources in an R&D environment.

In this study, management control is understood as the process of organising resources and directing activities that follow strategy and are intended to achieve certain objectives. Management control, therefore, is essential in firms’ exploitation of their resources.

This chapter describes the various components (i.e., competitive advantage, firm performance, resources, and management control) of the Analytical Framework. The chapter concludes with a summary of the Integrated Analytical Framework.

4.1 Framework for Analysing Strategic Resources in R&D firms

The RBV is widely used in the R&D literature to explore and identify the critical resources used in successful R&D activities (e.g., Fredericks, 2005; Kandemir et al., 2006). Brown and Eisenhardt (1995) show that the firm’s resources are essential for successful R&D.

As described in Chapter 2, the RBV is based on the premise that competitive advantage and sustainable competitive advantage can be expressed in terms of
rente or above average returns (Barney, 1991; Mahoney & Pandian, 1992; Peteraf, 1993; Akio, 2005). Competitive advantage is achievable through market imperfections and conditions such as exclusivity or scarcity. According to Barney (1991, 1995), sustainable competitive advantage is achievable if the firm has strategic resources. These resources are the assets or inputs to the firm’s processes that allow it to increase its efficiency and effectiveness (e.g., Wernerfelt, 1984; Barney, 1991; Hunt, 1997).

It is often claimed that sustainable competitive advantage reflects a firm’s superior performance relative to its competitors (Fahy, 2000; Ma, 2000; Rose, Abdullah, & Ismad, 2010). This advantage, which results from successful strategy implementation, is the reason management seeks to improve its performance. Because the firm’s managers want to outperform their competitors, they must create greater value for customers than their competitors.

Researchers think the determinants of sustainable competitive advantage develop and strengthen over time (e.g., Barney 1991; Collins & Montgomery, 1995; Peteraf, 1993; Fahy, 2000). Therefore, in this study, the focus is specifically on performance as it relates to competitive advantage at R&D firms. The study, however, does not address the nature/calculation of superior performance or sustainable competitive advantage (i.e., how to earn above average returns). Furthermore, this study does not address performance and competitive advantage of R&D firms through comparisons with competitors, as some RBV researchers have (e.g., Peteraf, 1993; Ma, 2000; Rose et al., 2010). Instead, the study focuses on the strategic relevance of resources based in a theoretical point of view and prior research.

The performance of R&D firms in this study is examined in terms of the predetermined and expected performance at the three firms chosen for this research. R&D spending (e.g., investments) represents a minimum claim on the returns generated by the results of these expenditures. R&D spending is unlikely to be recovered in the event of closure or restructuring if the R&D firm fails because it cannot meet the competition. Therefore, managers at R&D firms, who have a fiduciary responsibility to the firm owners, need to establish objectives when they allocate money to R&D and then work to achieve these objectives.
4.1.1 Value, Rare, Imperfect Imitability and Non-substitutable: VRIN

Because only strategic resources help the firm achieve expected performance (Rose et al., 2010) and competitive advantage (Barney, 1991), the resources should be valuable, rare, difficult to imitate, and non-substitutable with other resources (Barney, 1991). See Figure 4.

Barney’s (1991) VRIN framework (see Chapter 2) is adapted here to determine if the resources of the three firms of this study are strategically relevant. It is not the study’s intention to determine if the resources have provided a competitive advantage although a reasonable assumption is that R&D firms require strategically relevant resources if they are to achieve competitive advantage.

<table>
<thead>
<tr>
<th>Value</th>
<th>Rare</th>
<th>Imperfect Imitability</th>
<th>Non-substitutable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the resource have the capacity to generate profit or prevent losses?</td>
<td>Is the firm’s resource unusual compared to the firm’s competitors?</td>
<td>Is the resource easy to copy?</td>
<td>Is the resource substitutable?</td>
</tr>
</tbody>
</table>

Figure 4: Questions about value, rareness, imitation, and substitution

Resources with Value are resources that the firm uses to conceive of or implement R&D, leading to efficiency and effectiveness (i.e., an expected level of performance). Question: Does the resource have the capacity to generate profit or prevent losses?

Rare resources are resources in short supply. Question: Is the firm’s resource unusual compared to the firm’s competitors?

Resources that are Imperfectly Imitable are resources that are not easy for competitors to copy. Question: Is the resource easy to copy?

Non-substitutable resources are resources that cannot be replaced with similar or substitutable resources that provide the same result and are owned by competitors. Question: Is the resource substitutable?

4.1.2 Resource Groups

The literature review showed that RBV is based on the assumption that a firm’s competitive advantage and sustainable competitive advantage (e.g., Wernerfelt, 1984; Barney 1991, Grant, 1991; Peteraf, 1993) and its performance (e.g., Fahy, 2000; Ma, 2000; Rose et al., 2010) are determined by the resources it owns
or controls. This perspective contrasts with the traditional and industrial economic perspective on organisations that points to the firm’s external environment as the explanation of its behaviour (Porter, 1980, 1985).

In the RBV, resources are stocks of assets that are associated in some way with the firm and can be used in products and processes (e.g., Peteraf, 1993). This study adopts Barney and Arikan’s (2001, p. 138) definition of resources: “Firm resources are the tangible and intangible assets firms use to conceive of and implement their strategies”. This definition means that capabilities are also resources (Barney, 1991) and that the firm’s capability of conducting its activities is limited by its resources (Grant, 1991; Andersén, 2005). Barney and Arikan (2001, p. 140) define strategy as “a firm’s theory of how it can gain performance in the markets within it operates”.

The RBV has been criticised for only dealing with competitive advantage that derives from resources the firm owns or fully controls. Studies have shown, however, that firms can actually extract value from resources that are not fully owned and controlled (e.g., Dyer & Singh, 1998; Gulati et al., 2000; Lavie, 2006, 2007). This study agrees that a firm’s competitiveness derives in part from external factors, and that it may enhance its performance from the value added acquired from external actors’ resources. Therefore, resources in this study refer to the resources the firm owns and fully controls as well as the resources it does not fully own or control.

This study draws on prior research that has explored the use of the firm’s R&D resources. R&D, a strategy and development activity, may take two forms: product development or process development. One recurring theme in the literature on such development is that firms need different types of resources that they can use, combine, and transform (see Section 2.2).

Whereas some prior studies argue that the firm’s resources support its competitive capacity (e.g., Wernerfelt, 1984; Barney, 1991; Grant, 1991; Peteraf, 1993), this study explores R&D resources in terms of their tangibility and intangibility. Therefore, both tangible and intangible resources, categorized in four resource groups, are discussed in this analysis. These groups are the following: 1) Technical Resources, 2) Financial Resources, 3) Human Resources, and 4) Relationship Resources. In this analysis, these resource ‘groups’ or ‘families’ are important R&D sources.

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4 Barney and Arikan (2001, p. 140) add emergent and intended strategies to this definition.
The analysis of resources begins with tangible resources followed by intangible resources. See Figure 5.

<table>
<thead>
<tr>
<th>Assets</th>
<th>Tangible</th>
<th>Intangible</th>
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<tr>
<td></td>
<td>Plants and Facilities</td>
<td>Skills</td>
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<td></td>
<td>Test Equipment</td>
<td>Competence</td>
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<td></td>
<td>Manufacturing and Production Equipment</td>
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<td></td>
<td>Information technology systems</td>
<td>Know-how</td>
</tr>
<tr>
<td></td>
<td>Cash</td>
<td>Relationships with external actors</td>
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<tr>
<td></td>
<td>Technical Resources</td>
<td>Human Resources</td>
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<td>Technical Resources</td>
<td>Human Resources</td>
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<tr>
<td></td>
<td>Financial Resources</td>
<td>Relationship Resources</td>
</tr>
</tbody>
</table>

Figure 5: Summary of the four resources R&D firms require

*Technical Resources* are the tangible resources used in technical activities in the development process (e.g., Mitchell & Zmud, 1999; Kandemir et al., 2006). Other studies list plants and facilities of different kinds, and testing, production, and manufacturing equipment as well as information technology systems as technical resources.

*Financial Resources* are the tangible resources that provide R&D financing. This study adopts Vietes and Calvo’s (2011) definition of financial resources to include cash.

*Human Resources* are intangible resources in R&D. These are the people who do the actual work of, among other things, design, testing, and commercialization (see Cooper & Kleinschmidt, 1986; Tushman & Nadler, 1986; Song & Noh, 2006). People have knowledge, which includes skills, competence, know-how and experience (Teece et al., 1997; Verona, 1999). Such knowledge involves understanding situations and facts and knowing how to solve problems (Kogut & Zander, 1992).

*Relationship Resources* are the intangible resources in R&D that are not fully owned or controlled by the firm. As Lavie (2006, 2007) writes, the literature recognises that the RBV does not satisfactorily acknowledge the value of resources obtained by the firm’s external interactions. Prior R&D research concludes that R&D
firms benefit from the resources and capabilities that other firms and institutions have (e.g., Ragatz et al., 1997; Lührhe & Herstatt, 2004; Enkel et al., 2005).

![Diagram of VRIN Model]

**Figure 6: Analytical Framework - Resources**

Figure 6 summarises the first part of the Analytical Framework. The Analytical Framework assumes that strategic resources are essential for achieving predetermined and expected performance and competitive advantage. If a firm’s resources have the VRIN attributes, they are strategically relevant resources.

### 4.2 Framework for Analysing Resource Management in R&D Firms

In accounting, the balance sheet presents a firm’s financial position at a specific point in time. The balance sheet is a quantitative summary of the firm’s assets, liabilities, and equity. Since resources are assets, the balance sheet offers a starting point for the analysis of a firm’s resources.

Simons et al. (2000, p. 21) state: “In accounting, an asset is defined as a resource owned or controlled by the entity that will yield future economic benefits”. Thus, in accounting, assets not owned and not controlled by the firm do not appear on the balance sheet. This is consistent with the RBV that does not include shared resources in its conception of resources.

In accounting, a firm’s assets are categorized as current or non-current, depending on the time period in which their value will be realised. Technical resources,
which are tangible, are non-current assets. However, some intangible assets – e.g., goodwill, patents, and copyrights – are also non-current assets. Financial resources can be both current and non-current, although cash is classified as current. However, human resources and relationship resources, which are intangible, non-current assets, are not on the balance sheet.

Goodwill, an intangible, non-current asset that results when an acquiring firm purchases an acquired firm at a market price that exceeds book value poses special problems in accounting (Andrén, Eriksson, & Hansson, 2003, p. 252; Mejorada, 2004, p. 109). An acquiring firm will pay for goodwill because of assets (e.g., employees’ knowledge and skills, firm location and reputation, and good relationships) that are not on the acquired firm’s books. As Simons et al. (2000, p. 21) note “A resource may or may not appear as an asset on the balance sheet”. Various intangible assets are buried in the line item “goodwill” on the balance sheet.

A firm must own or control certain resources if it is to conduct successful R&D activities that help it stay competitive. Static firms simply focus on the ownership of sufficient resources for the conduct of R&D activities. However as number of researchers observe, ownership of resources is not enough. Dynamic firms must be able to exploit their resources by combining them in organisation processes aimed at specific results: products, processes, or services (Grant, 1991; Helfat & Peteraf, 2003; Akio, 2005). The Analytical Framework draws on those studies that claim resources, as sources of successful performance and competitive advantage, should be exploited.

Critics of the RBV claim it overlooks management of resources as the catalysts of competitive advantage. Researchers such as Aaker (1989), Porter (1991), and Mahoney and Pandian (1992) conclude that firms must exploit their resources as sources of competitiveness. Therefore, inspired by Penrose’s (1959/2009) early insights and the debate on resource exploitation, the Analytical Framework is partly based on a resource management perspective. Thus, the Analytical Framework takes into consideration that resources are organised, activities are directed, and resources are exploited in R&D.

Management control is the process of organising resources, directing activities, and exploiting resources in order to follow strategy and achieve desired objectives. It is an organisational component that enables effective resource exploitation (e.g., Barney, 1995; Barney & Mackey 2005, p. 10; Barney & Clark, 2007, p. 67; Barney & Hesterly, 2008, p. 90).
Managers are the leaders responsible for this process. In its focus on this managerial responsibility, this study discusses resource exploitation in terms of resource management. In prior studies, management is part of the firm’s human resources. The Analytical Framework assumes that the firm’s managers, who are generally profit-motivated, organise resources and direct activities in accordance with the firm’s objectives and strategy. Thus, resource management involves responsibilities, expected performance levels, and results.

In this study, the assumption is that a collection of control mechanisms (i.e., a toolbox of control instruments) supports management (Merchant & Van der Stede, 2012, p. 16). These mechanisms are designed for and used by management to control that the R&D firm reaches its predetermined and expected performance level.

The literature on management control reveals that the toolbox of control mechanisms is quite varied. One tool is organisation structure. Simons et al. (2000) explain that organisation structure is a resource that managers may use to provide a framework for strategies. They write that managers must decide how to organise the firm so as to achieve its strategy (p. 38). According to them, managers must facilitate the firm’s daily workflow by using the structure of the organisation.

Therefore, the Analytical Framework reflects the importance of organisation structures for the firms studied here. By organisation structure, the study refers to the design of the firm that specifies the formal reporting relationships, procedures, communications, authority lines, decision processes, and areas of control (e.g., country, region, product line).

4.2.1 Levers Of Control - LOC

The management control literature reveals there are various ways to discuss control in organisations (Simons, 1994; Berry et al., 1995, p. 3; Malmi & Brown, 2008) as well as different ways to categorise control processes and activities (Lövstål, 2008). Malmi and Brown argue that researchers should be more explicit as far as the kind of control mechanisms discussed because of the many labels used. As observed above, R&D is associated with potentially profitable innovations in its goal of offering customers new and improved products and processes (e.g., Brown & Eisenhardt, 1995).
The process of developing products and processes is interdisciplinary and requires contributions from many organisation functions (Ulrich & Eppinger, 2008, p. 3). Development involves a series of activities that are usually led by different departments or teams, each with its own structure, skills, people, and other resources (Barclay & Benson, 1990; Ulrich & Eppinger, 2008, p. 3). See Appendix 1.

It is common to conduct R&D activities in development projects. This structure, typical in Swedish industry has an important role in providing customers with complex systems (Dahlgren & Söderlund, 2013, p. 36). Management’s challenge is to organise the firm’s resources and direct its activities in accordance with strategy so that goals are achieved given resource limitations. Simons et al. (2000, p. 4) explains the management problem:

The heart of the problem is a series of tensions – between innovation and control; between profitability and growth and between your goals and those of your employees (and who have an interest in the business); and between the various opportunities to create value in the marketplace and the scarce amount of time and attention available to you.

This study focuses on resource management in the R&D environment. Therefore, the Analytical Framework acknowledges the R&D challenges. For this reason, the study uses Simons’s (1994) definition of control and his LOC framework (1994, 1995, 2000). The LOC framework is a good choice because of its focus on achievement of strategic goals, strategic renewal, and balancing the tension between innovation and control demands in R&D. Simons claims that the appropriate combination of the different control systems can meet the firm’s need to balance innovation and constraints. His definition of management control encourages the integration of financial and non-financial performance measures “Management control systems are formal, information-based routines and procedures managers use to maintain or alter patterns in organisation activities” (1995, p. 5). [Emphasis in the original]

The second part of the Analytical Framework relies on Simons’s LOC framework. His framework is based on the idea that information in an organisation flows along four different streams. Two streams flow down and two streams flow up (Simons, 1995, p. 6; see also Jeanson & Sundström, 2014). The two down streams focus on the strategic domain and the strategic plans. The up streams focus on the progress of strategies and related information about emerging
threats and opportunities. Simons writes four different systems, or levers, control each stream.


The way in which the three firms of this study exploit their resources (i.e., strategically relevant resources and less strategically relevant resources) is analysed using these four systems. This analysis is intended to show if the firms are organised to exploit the full competitive potential of their resources. The analysis also reveals how resources are used, combined, and transformed.\textsuperscript{5} Consistent with Simons’s suggestion, when the four systems are used to organise resources and direct activities, the firm should be able to manage the tension between innovation and the control demands. See Figure 7.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure7.png}
\caption{Analytical Framework - Management Control}
\end{figure}

\textsuperscript{5} Some researchers have questioned if the RBV encourages circular reasoning. Fahy (2000, p. 100) remarks on this issue: “[…] value, can only be assessed in terms of a particular context (Barney, 1991; Kay, 1993). Resources may lead to competitive advantage but this in turn defines relevant competitive structures, which in turn defines what is a valuable resource, and so on (Schendel, 1994). A way out of this circularity is to see the relationship between resources and advantage as a longitudinal process (Porter, 1991)”.

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**Belief Systems** are the explicit set of organisational definitions that managers “communicate formally and reinforce systematically to provide basic values, purpose and direction for the organization” (Simons, 1995, p. 34). Belief Systems, which encourage the search and discovery at the firm, are considered positive systems.

**Boundary Systems**, which communicate specific risks to be avoided, are used by managers “to establish explicit limits and rules which must be respected” (Simons, 1994, p. 170). They are considered negative systems because they define the limits of the search activities encouraged by the Belief Systems.

**Diagnostic Control Systems** are the traditional feedback systems used “to monitor organizational outcomes and correct deviations from pre-set standards of performance” (Simons, 1994, p. 170). These systems monitor and adjust operating performance and control critical performance variables.

**Interactive Control Systems** are the systems used by managers “to regularly and personally involve themselves in the decision actives of subordinates” (Simons, 1994, p. 171).

The additional question: “Is the firm organised to exploit the full competitive potential of its resources?” This is the last condition in Barney’s evolution of his VRIN framework, which is today known as the VRIO framework (Barney, 1995; Barney & Mackey, 2005, pp. 6-10; Barney & Clark, 2007, p. 70). See Figure 8.

<table>
<thead>
<tr>
<th>Value</th>
<th>Rare</th>
<th>Imperfect Imitatibility</th>
<th>Non-substitutable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the resource have the capacity to generate profit or prevent losses?</td>
<td>Is the firm’s resource unusual compared to the firm’s competitors?</td>
<td>Is the resource easy to copy?</td>
<td>Is the resource substitutable?</td>
</tr>
</tbody>
</table>

Figure 8: An additional question on organisation

The intention in taking the management control perspective is to determine if last condition of the VRIN(O) framework is fulfilled as well as to illustrate, in greater detail, how R&D firms exploit their resources.
4.3 Summary of the Integrated Analytical Framework

According to the literature, the RBV and management control are useful for increasing our understanding of R&D firms’ performance (i.e., how they achieve expected levels of performance and stay competitive). Figure 9 presents the analytical tools and concepts used in this study, summarised as the Analytical Framework.
The empirical focus of this study

Figure 9: The Integrated Analytical Framework
Chapter 5: METHOD

There are only two kinds of people of this world. The realists and the dreamers. The realist knows where they are going and the dreamers have already been there. ~ Robert Orben

What is science? This is a question that philosophers of science have tried to answer for centuries. Some people say that science is simply about understanding, explaining, and predicting our world. Others say that science is distinguished by the research methods used to investigate the world (Okasha, 2002)

The research question of this study is: Which conditions are needed for R&D firms to stay competitive? In answering that question, the study contributes to the RBV in its application to resource management at R&D firms. This chapter describes the research method used to answer that question.

5.1 Initiating the Study: An Explorative Historical Pilot Study

This study, which is explorative, began as a pilot study (in the Autumn, 2007) intended to learn about the Swedish firm, Svenska Fläktfabriken AB (SF), and its fate after the Swiss multinational, ABB, acquired it at the end of the 1980s.

A general assumption in this study is that tradition and experience influence a firm’s development. Thus, it is essential to study a firm’s history. One needs to investigate the time, place, and context of a firm’s development.

SF did not exist as an independent firm when this research was conducted. Therefore, the investigation required taking the historical perspective. As Florén and Ågren (2006, p. 69) state, this means the researcher is studying a fixed reality. According to Yin (2006, p. 6), researchers who study historic events have to use the history research methods. That is how the pilot study of this research was conducted.
In history research, researchers study different sources from the past (Stanford, 1995, pp.169-170; Florén & Ágren, 2006, p. 69). Thus, researchers who conduct historical studies primarily use empirical data they trust.

In its review of SF’s history, this study has similar empirical characteristics to those of historical studies. Historical studies focus on the relationships between context and phenomena in the past (Yin, 2006, p. 31). These phenomena are often rich and complex. Historical thinking, whether it concerns national history, industry history or a single firm’s history, gives us a useful check on certain ideas, even when the historian’s ability or desire to make a full-scale historical analysis is lacking (Goldman, 1994).

Furthermore, because the *pilot study* lacked a specific research question, its point of departure was the empirical data. A theoretical perspective was irrelevant. It is common to refer this approach to producing knowledge as the inductive approach. The inductive approach means that scientific knowledge is obtained from empirical data by inductive reasoning. The data collection takes place before any theoretical knowledge or perspective is acquired.

However, when the *pilot study* was conducted, I had considerable knowledge of industrial firms and industrial development. Prior to entering the doctoral programme, I had earned a Master’s degree in mechanical engineering. In this period of study, I also gained an understanding of firm management and development and acquired theoretical knowledge on product design and development and management accounting. In my graduate courses, I also studied industrial renewal.

According to philosophers of science, there are several required conditions in order to apply inductive reasoning to observable data, leading to scientific laws (e.g., Bendassolli, 2013). However, this study makes no such claims because it does not emphasise the generation of laws and principles based on a large number of observations. The *pilot study* on SF and the air treatment industry (fans, ventilations, dryers, etc.) did not aspire to generalisations from quantitative data although it had some inductive characteristics.

When historians study the past, they try to construct a realistic picture of past events. A historian’s responsibility is to gather facts about the past and then verify these facts using source-critical methods (Tosh, 2000, p. 141).
In this study, adopting the methods historians use, I initially tried to construct a painting of certain past – that, is to portray a reality that others would recognize (Dahlgren & Florén, 1996; p. 37, Florén & Ågren, 2006, p. 15).

However, it is neither possible nor desirable to create an image that exactly portrays this reality in all its details (Florén & Ågren, 2006, p. 86). Historical interpretations of individuals and events are subjective (Stanford, 1995; Tosh, 2000). According to Tosh (Ibid. p. 141), generalisations in the social sciences are not applicable in studies of the past; history cannot offer universal laws. Therefore, the history examined in the pilot study was used to acquire an understanding of why and how certain events occurred. This was a study of past decisions.

5.1.1 Important Empirical Findings from the Pilot Study
The study and analysis of SF’s history revealed several interesting facts. SF, which was later renamed Fläkt AB, had created new products and processes before it was acquired by ASEA and (and later sold) by ABB. This creative capability can partly be explained by the R&D activities that its subsidiary, Fläkt Industry (FI), conducted.

With the merger of ASEA and Brown Boveri (now ABB), Fläkt AB was absorbed into the new electro-technical group. Subsequently, Fläkt AB became a fully owned subsidiary of the Swiss ABB group, before it was disassembled into different activities. Each of these activities was absorbed into the relevant sector in ABB’s matrix structure. Because of a business decline, FI’s business areas were sold to four other multinational corporations: Alstom, Andritz, Dürr, and Fläkt Woods. See Figure 10.

![Figure 10: The arrows show how SF entered ASEA and ABB, and later sold to four other multinational corporations: Alstom, Andritz, Dürr, and Fläkt Woods.](image-url)
A second fact of interest was that FI’s four business areas were still operational at these four multinational corporations. Three of FI’s four business areas still operated in Sweden, in the same city where FI was located before it was sold. The fourth area, which Dürr acquired, was relocated outside Sweden.

5.2 Research Design

The empirical findings from the pilot study caused me to think about globalisation, global industrial competition, and industrial renewal. I also thought about the current debate on restructuring of firms and firm competitiveness, particularly as the debate has flourished in Sweden. As a result, I began extensive reading on firm competitiveness, resources, and resource management.

Thus, the overall study, which originated in the explorative pilot study, was a process of searching and learning. The ambition of this qualitative case study was to contribute to the theory on the RBV (see Chapter 2) by combining an iterative approach (with a focus on resource management at R&D firms) and a management control perspective.

A case study is a record of an event, a history of the past, or a description of a current phenomenon drawn from various sources (Leonard-Barton, 1992). The case study methodology was adopted for this study that deals with both current and past events (see Eisenhardt, 1989; Yin, 2006, pp. 24-25). Furthermore, as Armstrong and Shimizu (2007) argue, the qualitative approach may provide a deeper understanding and development of the RBV.

Most RBV studies take a quantitative approach. However, this study aimed to understand the phenomena of three firms’ competitiveness. Understanding something as complex as competition requires extensive and comprehensive data that can best be obtained with the qualitative approach (Eisenhardt, 1989; Strauss & Corbin, 2008, p. 13). For these reasons, I took a qualitative approach in this research.

The case study method is appropriate when describing processes (Eisenhardt, 1989; de Weerd-Nederhof, 2001). Moreover, R&D researchers are very familiar with this method because it is often used in R&D studies of product development. In such studies, researchers can ask in-depth and probing questions that lead to the discovery of more details than might have been found by other research methods (Rahim & Baksh, 2003). The case study method of this study...
involved field research and empirical descriptions (Denzin & Lincon 2003, p. 16) of the history of SF, FI, and the three R&D firms acquired by the multinational corporations.

5.3 Line of Action

Before conducting a case study, the researcher has to choose between a single-case study design and a multiple-case study design (Leonard-Barton, 1992; Miles & Huberman, 1994, pp. 25-26). Results from multiple-case studies are more rigid than single-case studies although the design of the former is more demanding (Miles & Huberman, 1994; p.29, Yin, 2006, p. 68).

The *pilot study* was a single-case study in its examination of the history of SF, Fläkt AB, and its subsidiary, FI. The decision to study multiple cases in the *overall study* was made during the *pilot study* when I researched the joint history of SF, Fläkt AB, and FI. At this point, I decided to include more cases in the *overall study*. A multiple-case study facilitates comparisons (e.g., Yin, 2006, p. 74).

The *overall study* analyses three R&D firms (i.e., Alstom Power, Andritz AB, and Fläkt Woods). As discussed in chapter one, an R&D firm is competitive when it has dealt with external and internal competition over time, and thereby has defended its external position in the market and its internal position in an industrial group. Therefore, Dürr, which acquired the paint finishing operations of FI, is not in the *overall study*.

The three firms – Alstom Power, Andritz AB, and Fläkt Woods are established industrial firms and are engaged in R&D for products and processes in the area of air handling technology. Their respective multinational corporations have their headquarters in different European countries. The R&D firms differ in size and in the development of products and processes for different industries. Therefore, their competitive landscapes vary, depending on their core businesses.

5.3.1 Data Collection

This study uses a combined method of data collection, which is a common approach used in case studies (Eisenhardt, 1985). Data collection began in 2007 (at the time I began my doctoral studies) and concluded in 2011. I conducted interviews in the *pilot study* aimed at collecting information about SF’s business areas, in particular R&D at FI. Obviously, as a researcher and not an employee, I could
not participate in or observe the R&D work directly. My interviews were with former employees who had been involved in the R&D.

I identified these former employees using snowball sampling for the pilot study. Names of suitable people emerged during the study. I contacted them by email and by telephone. Six interviews were face-to-face; three interviews were by telephone. Most interviews were conducted in 2009 although the first interview was conducted in 2007. I also conducted follow-up interviews and sent emails to gather more data. These took place in 2011. See Appendix 2 for a summary of the interviews in the pilot study.

I found that archival data were an important source of information about SF and FI. The archival data included publications (e.g., newspaper articles and firm brochures) and other materials provided by the former employees. The National Library of Sweden in Stockholm preserves archival data for the benefit of the public (Kb.se). I found archival data on SF, Fläkt AB, and FI at this library on several occasions. I also collected data on the firms’ histories from previous studies on SF, Fläkt AB, and FI (e.g., Löwstedt, 1986, 1988; Dobers, 1997; Andersson, 2002, 2004).

I collected data for the overall study primarily in interviews. These interviews were conducted during several day visits to the three firms. I first contacted the manager of each firm or the manager of the R&D Department. These managers identified other possible informants (i.e., employees who were involved in the firm’s R&D). In order to confirm their involvement and their role as key informants, I asked them to describe their background and position at the firms. I also asked them for names of other employees involved in the R&D activities. In this way, I obtained interviews with both managers, employees and former employees.

I conducted 32 face-to-face interviews. Another interview was by telephone and another was by email. I conducted 16 interviews with informants at Alstom Power R&D Execution, 8 interviews with informants at Andritz AB, and 10 interviews with informants at Fläkt Woods. These interviews were mostly conducted in 2009 and 2010. In 2011, I conducted follow-up interviews with the informants and sent them emails with questions. See Appendix 3 for a summary of the interviews in the overall study.

I did not determine in advance the number of interviews I would conduct. I simply conducted interviews until the empirical data saturation point was
reached, after which additional interviews would not provide relevant data (Glaser & Strauss, 1967; Morse, Barett, Mayan, Olson, & Spiers, 2002; Esaiasson, Giljam, Oscarsson, & Wängnerud, 2007). After a number of interviews, new informants began to repeat the same information that other informants had given. Several informants, currently working with the R&D at the three R&D firms, had also worked at FI. Therefore, they could give detailed information about FI.

I collected archival data that complemented the information from the interviews. The archival data was obtained from firm websites, press releases, various publications, and other materials provided by the employees. I also documented my informal observations in the visits to the firms.

In total, I conducted 9 interviews for the pilot study and 34 interviews for the overall study. These interviews were conducted over a period of 43 months. The first interview was in November of 2007; the last interview was in June of 2011. All face-to-face and telephone interviews were recorded using a MPEG-1 Audio Layer 3 (MP3 Recorder).

These interviews were later transcribed. I used my notes from the interviews to complement the transcriptions. The interviews varied from thirty minutes to two hours. Most face-to-face interviews were in Växjö, Sweden, at the firms or at Växjö University. One interview was in Eskilstuna, Sweden, at Mälardalen University, and one interview was in Stockholm, Sweden.

The interviews were relatively unstructured although they followed a series of question themes. See Appendices 4 and 5. The interviews began with questions related to the informant’s background and experience at the firm. The intention was obtain information about the informant’s education, previous work experience, and work at the R&D firm.

In the second phase of the interviews, my objective was to learn about the informants’ work tasks. I asked them to describe and explain their responsibilities, their involvement in the development process, and their work with respect to their responsibilities and the R&D activities. The pilot study established that some employees had worked at FI. These employees were asked to describe their experience related to the acquisitions.

Interview transcriptions can be made at different levels of detail. All interview transcriptions for this study repeated the informants’ words and expressions (Miles & Huberman, 1994, p. 51). Pauses were excluded in the transcriptions so
that the informants’ transcribed comments resulted in a clear and straightforward summary. The focus was on the R&D process itself and not on the informants’ manner of description. This was a conscious decision that facilitated the analysis of the compressed raw data (Lantz, 1993, p. 77).

The informants were given the opportunity to review and correct (as needed) the transcriptions of their interviews. The documentary data (e.g., archival data) were used to complement/validate the interview data as well as provide additional information on the firms.

Together, the interviews and other data were used to create case stories of each firm. These case stories were used as the basis for more extensive interviews with managers at the three R&D firms. The purpose of this set of interviews was to resolve the questions that arose in writing and comparing the case stories and to acquire more precise information about the resources and resource management. The questions in this second round interview were adapted individually to the respondents. For example, after learning the responsibilities related to positions in the organisation, the managers were specific questions about strategy and management control; the engineers were asked specific questions about the R&D project work. In sum, the interview transcriptions, the researcher notes, and the archival data were used to construct the three firms’ case stories.

5.3.2 Construction of Case Stories and Case Analysis

To begin the analysis of the case stories, thick, chronological descriptions of SF, Fläkt AB, and FI were created.

Some of the data were reduced and simplified in the SF and Fläkt AB case story in order to focus on the development of the business areas at the firm. After defining its beginning and end, the story was divided into time periods in accordance with specific firm events. These separate time periods became evident as the life cycle of the firm was analysed – the period when various firms (i.e., ASEA and ABB) acquired SF and Fläkt AB, and the period following these acquisitions.

Case stories were created for the three R&D firms: Alstom Power, Andritz AB, and Fläkt Woods. These stories, which were also constructed from interview transcriptions, notes, and archival data, were treated as a single time period. This chronology was appropriate because the three corporations (ASEA, FI, and ABB) held these business areas for only a short time. In fact, these three firms are still owned by the same multinational corporation that acquired them.
An inductive research approach means that categories should emerge from the empirical data rather than from theories (Glaser & Strauss; 1967, p. 3 Eisenhardt, 1989). Glaser and Strauss describe that the constant comparative method requires coding in a conceptual category; this coding is then compared with the previous category (Ibid. pp. 22-23).

Initially, it was possible to code the data as Glaser and Strauss (1967) recommended. However, it was decided to use their recommendation as inspiration only to minimise the risk that coding the empirical data could disrupt the accounts of the firms’ histories. The concern was that coding the data created the possibility that important events in the firms’ history could be lost.

Data analysis was divided into four stages. In the first stage, the processing of the data and the creation of the case stories from the interview transcriptions, notes, and archival data began. Software programmes such as Nvivo were not used in the creation of these stories. Instead, using highlighter pens, the data were related manually to the different aspects. This system reduced the risk of losing data.

Inspired by Brown and Eisenhardt’s (1995) study design that takes an inductive approach, this stage required analysis of the multiple-product development portfolios of the strategic business units and the interview responses. Responses to the same question were treated as a single response. Furthermore, some interview responses, which addressed other aspects, were linked to other questions.

In the second stage, gaps among the case stories were identified. During the construction process of each single-case story, minor comparisons between the cases stories were made to identify gaps and missing information. In this way, data collection and analysis for each case story were conducted interactively. The benefit of this type of analysis is that is allows the researcher to think about the data and to develop better procedures for collecting new and better data (Miles & Huberman, 1994, p. 50).

In the third stage, the case stories were analysed. This analysis began with the creation of three maps of key resources for the three firms’ R&D. Examples of resources that were mapped included individuals, offices, and test facilities. These resources were then sorted according to groupings identified in previous studies. The resource maps were compared with each other, and a summary was created that identified similar and different resources used in R&D. See Figure 16. The summary was then compared to resources identified in previous studies to determine that no resources were omitted and to ascertain whether the firms owned
resources that previous studies had not identified. This was an iterative process, which meant going back and forward between the case stories and the previous studies.

Because the interviews were the main data source, it was necessary to use the interview data to identify the firms’ resources. This, in turn, meant that intangible resources such as knowledge and relationships were not identified by observations. However, previous studies have used interviews to identify and study intangible resources (e.g., Brown & Eisenhardt, 1995).

Another map was drawn that linked the resources to the stages in the development process and that identified where and how they interacted in the process. At this point, the case stories were again examined through comparisons that identified similarities and dissimilarities in resource management.

In the fourth stage, each case story was analysed in relation to the first part of the Analytical Framework, which is based on Barney’s (1991) VRIN framework that identifies strategically relevant resources. Each case story was next analysed in relation to the second part of the Analytical Framework, which is based on Simons’s (1994, 1995) LOC framework that focuses on the organisation of R&D resources and the direction of R&D activities (see also Ouchi, 1977; Govindarajan & Gupta, 1985; Cardinal, 2001).

In summary, in the first three stages the case stories were analysed jointly in order to make generalised summaries of resources and their management. However, in the fourth stage the case stories were analysed separately in order to examine each R&D firm.

5.3.3 Development of the Integrated Analytical Framework
During the data analysis, as research results appeared, the issue of firm competitiveness began to take form. At that point, it was of interest to learn more about such competition as explored in prior studies. Additional literature was collected from libraries, and electronic databases were used to search for relevant articles. Literature suggestions were also made in a doctoral course.

This literature review led to the understanding that competitive advantage is a central concept in the literature on strategic management. Many researchers have studied competitiveness from within and without the firm. Some researchers focus on the effect of the firm’s external environment (e.g., Porter, 1980, 1985,
1986). Others focus on the effect of the firm’s internal environment (e.g., Wernerfelt, 1984; Barney, 1991; Peteraf, 1993).

Using the findings from the pilot study (i.e., the capability to create new products and processes at SF), the study of the RBV intensified since that perspective is based on the idea that sources of competitive advantage are found within the firm, more precisely, in its R&D. It was clear that the RBV literature dealt with competitive advantage, sustainable competitive advantage, rents, resources, capabilities, and dynamic capabilities.

Additionally, the literature on management control required more study. It was apparent that the management control literature dealt with strategy, control, and performance. This literature review revealed that the RBV and management control have been used in the R&D literature to explore success factors in R&D.

Based on this literature review, an Integrated Analytical Framework was developed that would increase our understanding of the conditions R&D firms require to remain competitive. The first part of the Integrated Analytical Framework was based on the RBV. The focus was on resources and the VRIN Framework developed by Barney (1991).

The literature review also led to the understanding that the VRIN framework assumes that if a resource has the VRIN attributes (i.e., Value, Rare, Imperfect Imitability and Non-substitutable) it can be considered a strategic source of firm’s competitive advantage. Barney’s (1995) improvement of his framework led to the recognition that resources and capabilities as organisation components of management control should be explored. Thus, the Integrated Analytical Framework was further developed to include the management control perspective and to incorporate Simons’s (1994, 1995) LOC framework.

5.3.4 Level of Analysis

When a multinational corporation purchases all or most of the shares of a firm, the acquired firm becomes a foreign sub-unit or subsidiary unit of the multinational corporation. See Figure 11.
An acquired firm controlled by a multinational corporation is (usually) expected to obey corporate-level strategic decisions. However, as Bowman, Duncan, and Weir (2000) suggest, while headquarters generally make the strategic decisions, the subsidiaries or sub-units often make the operational decisions.

Because there was little possibility to integrate the multinational corporations in the design of the study, the relationship between the three R&D firms and the multinational corporations was not explored. The focus of the study remained on the individual firms and their R&D.

Nevertheless, it was very clear from the resource management analysis that the corporate-level managers influenced firm-level managers (see Andersson, Forsgren & Holm, 2002, for a detailed discussion on subsidiary performance and competence development in multinational corporations). The informants described this situation in the interviews, but the study has no confirmatory evidence from top management.

5.3.5 Some Quality Considerations
Reliability and validity are very important concepts in all research disciplines. These concepts, which are used to evaluate the quality of research design and data collected, have their root in a positivist epistemology. Reliability focuses on determining if research results are consistent over time and if they can be reproduced using similar methodology. Validity focuses on determining if the research results truly measure the intended objective (Golafshani, 2003).
Kirk and Miller (1986, p. 19) present a vivid example of how reliability and validity differ. It is known that water boils at 100 °C at a certain pressure. The temperature of boiling water can be measured using a thermometer. If the thermometer reads 100 °C each time it is dipped in the boiling water, we conclude the thermometer is reliable. However, if a second thermometer shows the temperature varies from 100 degrees, we conclude the thermometer is unreliable although still valid.

Concepts are often used in quantitative research although researchers have shown that concepts apply equally well to qualitative research (Yin 2006, pp. 54-59). Some researchers have questioned the direct application of concepts to qualitative research (e.g., Stenbacka, 2001, Morse et al., 2002). Therefore, the following discussion focuses on steps needed to ensure the quality of the research design.

For this study, various steps were taken to enhance the quality of the collected data and thereby the quality of the study. According to Stenbacka (2001), research quality is achieved using the qualitative approach when the understanding of the phenomena is profound. It has been suggested that this understanding is more probable if a study’s informants are involved in the problem area and understand it (Stenbacka, 2001; Morse et al., 2002).

The informants in this study – the managers and other employees from the three firms – had been previously involved in the R&D (pilot study) or were currently involved (overall study) in the R&D. They had in-depth depth knowledge of the development process. Thus, they were suitable as informants on the firms’ R&D. Their selection as informants ensured the validity of the research (see Stenbacka, 2001; Morse et al., 2002).

The fact that the informants were allowed to speak freely supported the quality of the study (see Lantz, 1993, p. 58). The informants could define the phenomena from the open-ended questions in the interview guide that connected to certain themes. Although the interviews questions were more structured and directed in the latter phase of the study, the informants still could express their views on the subject and answer freely.

In the analysis, multiple data sources were used. Multi-method research allows the researcher to achieve high quality in research that takes the qualitative approach (Yin, 2006, pp. 127-128). Multi-method research also allows comparisons of data. For example, in this study the informants’ responses were compared with
other informants’ responses. The responses were also compared with the archival data.

The interviews provided most of the information for this study. In interviews (and observations) it is always possible to misunderstand or misinterpret something. Such problems mean case stories are likely to be incomplete or erroneous. In the expectation that these problems could be avoided, the informants in this study were allowed to read the transcriptions of their interviews and make corrections and additions as necessary. The risk in interviews about past events is that people often find it difficult to recall events exactly. They may then present misleading accounts (Florén & Ågren, 2006, p. 74.).

The overall study grew out of the findings from the pilot study that resulted in a firm history of SF, Fläkt AB, and FI. As in any other historical study, there was an attempt to reconstruct the past in a way that would shed light on this history. Therefore, to ensure the quality of the information about the past and procedures of SF, Fläkt AB, and FI, information from some former employees was compared with information from other former employees. The interview information was also compared with archival data including prior studies on SF, Fläkt AB, and FI (e.g., Löwstedt, 1986, 1988; Dobers, 1997; Andersson, 2002, 2004).

A case study is not the same as sampling, and statistical calculations are irrelevant (Stenbacka, 2001; Yin, 2006, pp. 57-58). The focus of case studies should be on the analytical generalisations rather than generalisations based on quantitative data.

The use of informants who were familiar with R&D enhanced the quality of the study. Interviews were conducted until empirical data satisfaction point was reached (Glaser & Strauss, 1967; Morse et al., 2002). This required interviewing the first group of informants, interviewing additional informants, and returning to key informants to collect more information. This data collection method is consistent with Morse et al.’s (2002) advocacy of ensuring research quality by expanding the depth of data, addressing gaps, and obtaining adequate and appropriate information.

Morse et al. (2002) emphasise the importance of the role of experienced researchers in mentoring graduate students and new researchers. Such mentoring helps mentees learn to think qualitatively about their research. Additionally, such supervision allows students and new researchers to discuss and verify their work with their mentors.
This research was part of a graduate programme aimed to understand Industrial Renewal. The research was supported and mentored by research supervisors from the Swedish Research School of Management and Information Technology (MIT). In addition, because the research supervisors, their colleagues, and students were associated in various ways with Stockholm University, Mälardalen University, and Örebro University (as members of the MIT), other senior researchers and graduate students provide important review and feedback on this thesis.

Parts of this thesis were published as a book chapter in *Studies in Industrial Renewal: Coping with Changing Contexts* (Sundström, 2001). Parts of thesis were also presented at conferences. These conferences were: “Doings in Strategic Entrepreneurship - A study of how practitioners draw on practices in the opportunity-and advantage-seeking process” (Högland & Sundström, 2011); and “Exploring how R&D management control influences the outcome of R&D process: A case study of R&D Management Control in a Swedish R&D firm (Jeanson & Sundström, 2014). Writing the book chapter and preparing the conference papers were very helpful with the initial empirical analysis as these activities brought focus and clarity to the research ideas. The feedback on the papers was especially useful.

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6 The Swedish Research School of Management and Information Technology (MIT) is one of 16 national Research Schools supported by the Swedish Government. The MIT co-operates with the Blekinge Institute of Technology, Gotland University College, Jönköping International Business School, Karlstad University, Linköping University, Lund University, Mälardalen University College, Uppsala University, Växjö University, and Örebro University. The MIT is headed by Uppsala University. The research by MIT is divided into the three main areas – economic information systems, business administration, and informatics.” (forskarsholan-mit.nu, 2013)
Chapter 6: THREE CASES OF SWEDISH R&D FIRMS

Chapter 5 describes how Alstom Power, Andritz AB, and Fläkt Woods, in the 2000s, acquired different business areas and technology from Fläkt Industry AB (FI) owned by ABB. FI had initially been part of Svenska Fläktfabriken AB (SF). The development of FI's environmental business and fan technology continued in Sweden after the acquisitions but as separate R&D firms (i.e., sub-firms) called Alstom Power (i.e., R&D Execution), Andritz AB (i.e., Technical Centre) and Fläkt Woods (i.e., Centre of Excellence). Multinational corporations with headquarters in France (Alstom), Germany (Andritz), and Switzerland (Fläkt Woods) own these R&D firms.

This chapter describes these three multinational corporations and the three R&D firms in Växjö, Sweden. Alstom Power is involved in R&D for environmental control, Andritz AB is involved in R&D for drying processes for pulp, paper, and biomass, and Fläkt Woods is involved in R&D for large, axial fans.

The chapter begins with a description of the history of SF and its subsidiary, FI. The purpose is to give the reader an understanding of the origins of the three R&D firms.

Thereafter, case stories of three multinational corporations and their three R&D firms are presented. The empirical findings from comparisons of these case stories follow.

6.1 Painting the Picture: AB Svenska Fläktfabriken

At the beginning of the 20th century, two engineers from southern Sweden founded a firm they called AB Svenska Fläktfabriken, Söderberg & Co. (in English, the Swedish Fan Industry) also known as SF. The company was founded on April 15, 1918. At that time, technology in air handling was an unexplored area of research. SF became a pioneer in several areas of air technology (Andersson, 2004, p. 6).
In 1927, Ivar Kreuger, the Swedish civil engineer, financier, and entrepreneur, bought all SF’s shares. The Kreuger Group then owned SF until the Kreuger Crash in 1932. When ABB Group was created by the merger in 1988 of ASEA and Brown Boveri, SF (now called Fläkt AB) became a subsidiary to the newly formed ABB. ABB realised it needed to increase its ownership position in Fläkt AB so as to use the inter-firm synergies to the maximum level. The decision was to make Fläkt AB a fully-owned subsidiary of ABB. With full ownership of Fläkt AB (in 1988), ABB could exploit various, inter-firm synergies. Fläkt AB, which was then no longer a publicly traded company, disappeared from the stock exchange (Andersson, 2002, p. 201).

When it was absorbed into the ABB Group, Fläkt AB, which had originated as a small business, had become one of the largest environmental firms in Europe. Before Fläkt AB was acquired by ABB, the firm was highly successful with expansion over the decades into the purchase and development of various products and processes. These included heat recovery batteries in 1920, pulp dryers in 1929, electrostatic precipitators in 1940, VELOVENT systems for office blocks in 1953, L-pulp dryers in 1956, VENTURI separator systems for car painting in 1959, Fläkt paper dryers in 1963, DIRIVENT for industrial ventilation in 1973, and others.

The status of Fläkt AB began to change a few years after its acquisition by ABB. This change began toward the end of the 20th century. Fläkt AB had worked with ASEA, a Swedish electric company, for 59 years in independent groups with subsidiaries in many different countries. However, ABB decided to disassemble Fläkt AB into different activities. Each activity was brought into the relevant sector in ABB’s matrix structure.

After this disassembly decision, Fläkt AB and its environmental business (i.e., FI) experienced market losses. Eventually the ABB Group sold Fläkt AB’s various business areas at the beginning of the 21st century. Fläkt AB then vanished from the market. However, at the time of this writing, these various business areas are still active. They continue as new R&D firms with ownership by foreign multinational companies.
6.1.1. Acquisition of the Business Areas of the Former Fläkt Industry

For a time, Fläkt AB was a market leader in many countries. Today four multinational companies own those business areas that gave Fläkt AB its competitive advantage when the ABB Group acquired it. See Figure 12.

![Diagram showing the four business areas of former Fläkt Industry and their new owners: Alstom, Andritz, Dürr, and Fläkt Woods.]

Figure 12: The four business areas of former Fläkt Industry and the new owners

The entire power segment and the research laboratory in Växjö, Sweden, were sold in 2000 to Alstom Power of France. In 2002, the pulp and paper drying operations, which after the acquisition by the ABB Group were part of ABB Automation, were sold to the Andritz Group of Austria. The pulp and paper drying operations remained in Växjö for a while but were then sold along with the activities in Montreal. The paint finishing operations were moved to ABB Germany immediately after the acquisition, but were later sold in 2000 to Dürr, a former competitor with headquarters in Germany. Dürr is a supplier of products, systems, and services, mainly for the automotive industry.

The beginning of the end came in 2001 when ABB sold its air treatment business. Global Air Movement SARL bought the brand “Fläkt” and its air treatment activities. The air fan activity, which had been in Växjö, after the sale to Global Air...
Movement SARL became part of ABB Ventilation Products in Jönköping, Sweden. In early 2002, the Fläkt Woods Group was formed by the merger of Fläkt Industry and Woods Air Movement. The newly formed Fläkt Woods in Jönköping decided to move the manufacturing out of Sweden.

In sum, the story Fläkt AB and FI is an example of how a successful industrial firm can vanish from the market. Although the Fläkt Group is no longer a publicly traded entity, its former business areas and R&D activities still exist in Sweden. However, new R&D firms, owned by multinational corporations, conduct these activities.

This chapter continues with descriptions of the three multinational corporations – the Alstom Group, the Andritz Group, and the Fläkt Woods Group – and their R&D firms in Sweden.

### 6.2 The Alstom Group

The Alstom Group (Alstom) provides rail infrastructure and power generation. Alstom Transportation provides products to the railway sector including high-speed trains, light rail transit, metro systems, suburban and regional trains, locomotives, and freight trains. Alstom Power manufactures product and systems for the power generation sector in industrial markets.

Alstom, which works with all energy sources, offers the advanced solutions for coal- and gas-fired plants. Alstom also makes conventional islands for nuclear plants and renewable energy solutions such as hydro and wind power. Alstom has more than 80,000 employees and a presence in 70 countries. At the time of this writing, Bouygues, a French industrial group listed on the Paris CAC 40, owns Alstom. Bouygoues acquired the French government’s stake in Alstom in April of 2006.

In fiscal year 2008/2009, Alstom’s managed its activities in the power generation area in two sectors called Power Systems and Power Service. Power Systems dealt with plants, new equipment, and retrofit. Power Service focused on the aftermarket from up-grades to spare parts delivery and field service. However, in March 2009, Alstom announced that these two sectors would merge as the Alstom Power sector.
This new organisation has been set up to meet two main objectives. Firstly, the Group faces growing demand in the installed base and needs to optimize its offering to successfully address these opportunities. Secondly, this organisation will allow us to optimize Alstom’s sales efficiency, improving its cost base through common manufacturing and supply chain, fully coordinated research and development and controlled fixed costs. (Alstom Group, Annual Report 2008/2009, p. 12)

The organisation of this newly formed entity consists of the following six activities: Thermal Systems, Thermal Products, Thermal Services, Hydro, Wind, and Energy Management. Thermal Systems includes gas and steam systems as well as power plants and environmental control systems. Thermal Products includes gas, steam, and nuclear product lines. Thermal Services includes the retrofit, fleet management for all types of equipment, and the local service centre network. Energy Management is involved in regrouping instrumentation and control as well as automation products.

In Sweden, Alstom sells and delivers a broad range of products for transport and power generation. The head office is in Norrköping. Other main sites in Sweden are in Västerås, Växjö, and Stockholm. The firm employs approximately 800 people in Sweden, divided among the following three companies: Alstom Power Sweden AB, Alstom Hydro Sweden AB, and Alstom Transport Sweden AB. Besides product sales, the companies offer service and consulting, and are engaged in research and development. Local service centres for the power activities are in Kiruna, Gällivare, Piteå, Skellefteå, Sundsvall, Gävle, Västerås, Karlstad, Stockholm, Norrköping, Växjö, Göteborg, and Malmö. The transport activities are in Stockholm and Västerås.

6.2.1 Business areas and Performance
Alstom Power acquired the entire power segment and FI’s research laboratory in Växjö. This acquisition gave them control of FI’s environmental control area as well as technology such as electrostatic precipitators and sleeve filters (fabric filters, bag houses, etc.), all cleaning systems for sulphur dioxide (WFGD, Dry FGD, Drypac, NID, etc.), nitrogen dioxide with catalysts (DeNox), scrub for different gases, and cleaning systems for garbage incinerators. Alstom Power commented on their homepage:
ALSTOM Environmental Control Systems has a long-standing history as a supplier of air pollution control technologies. After successful mergers and acquisitions in Europe and in North America, we have gathered under the ALSTOM banner the best, world-renowned brands and technologies in the business, like the former Fläkt. (service.power.alstom.com, 2009)

Alstom Power Sweden AB in Växjö develops, sells and, maintains systems and products for air pollution control. Its focus is the minimisation of the risk of negative environmental damage. The firm sells and delivers complete flue gas cleaning plants, both for new power plants and for existing plants that want to upgrade to current standards. The firm designs and builds complete customised plants focused on removing environmentally harmful substances such as dust, sulphur dioxide, nitrogen oxides, and other hazardous substances from various types of process gases. It uses its cleaning technology mainly in the power and heating industries and for waste incineration. Other important customer categories include the iron and steel and the pulp and paper industries. Thus, the firm provides flue gas cleaning systems for all types of combustion processes that use fossil fuels and bio fuels. The firms’ principal R&D centre is also in Växjö.

6.2.2 Research and Development Organisation and Resources
Alstom Power Sweden has a large service facility in Växjö with several local offices in different areas of Sweden. The firm’s R&D centre (R&D Execution), which is considered one of the world’s best, is equipped with air technology laboratories. The main research is conducted at this centre. Process development for the Environmental Control Systems is also conducted at this centre. About 70 employees work at R&D Execution, which consists of four departments. See Figure 13.

The four departments are Technical Management, Process and Design, Fluid Dynamics, and Facility Management. Each department has its own manager who is responsible for a certain number of people.
Figure 13: Organisation Chart - Alstom Power Sweden (R&D Execution) in Växjö

*Technical Management* provides engineers (Technical Leads) to the various projects. As Project Leaders for development projects, they manage technical aspects and plans for the projects.

*Process and Design* is in charge of the designs and processes in the pilot projects. This department is also involved in the management of the laboratory tests.

*Fluid Dynamics* employs research engineers who work with the dynamics of fluids. These engineers are responsible for the fluid dynamics tests, in particular using the software CFD.

*Facility Management* provides employees who build the laboratory pilots. This department also has chemical engineers who conduct the chemical analyses.

Alston Power also has support functions: Patents, Control, Administration, Deputy R&D, and Laboratory.

Program Managers is a department (not shown in Figure 13) that has a large influence on development projects although it is not part of R&D Execution. The Program Managers, who deal with the economic aspects of projects, manage
the projects’ budgets. They are also responsible for management of the ideas for potential development projects.

Alston Power Sweden has two types of projects in Växjö: customer projects and development projects. These projects differ in their focus and organisation. Customer inquiries initiate the customer projects. These projects are conducted in Alstom Power’s main building in Växjö where the Sales Department is located.

Development projects originate with ideas that are thought to have promising potential. These projects are conducted at R&D Execution, which is near the main building. Thus, the engineers in the various departments of R&D Execution are mainly used in the development projects. However, R&D Execution also provides expertise to the Sales Department and to the customer projects as needed. The Technical Manager explained:

The department is now called R&D Execution. We carry out development projects, and we support the businesses with specialist competence in all our areas of technology. We do this globally so it’s not just the unit here in Växjö that we help. We also develop products for all markets and for all Alstom businesses that work in the environment control segment. We support all the business in Alstom that work with environmental technologies. We are a true global organisation.

R&D Execution works closely with other research laboratories in the Alstom Group (e.g., Kolkata in India, Knoxville in the United States, and other technical institutes around the world). With its contacts in many other countries R&D Execution is an international organisation. The Local Manager described the organisation:

Among the 50 employees who work here, some have their roots in China, Germany, France, Lebanon, Syria, Jordanian, the former republic of Yugoslavia, and Hungary. I’ve probably missed some [countries]. We have a relatively international work force. We are an international corporation.
The R&D activities at R&D Execution focus on the development of new and improved products and systems for air pollution control technologies and on the development of expertise on key technologies in air handling.

Project teams are assigned to the development projects.

Tests are conducted in these projects that are intended to develop better products and processes. The tests, which usually have different stages, must be conducted so as to meet market demands and to comply with various laws and regulations. Project teams must decide on the testing locations.

R&D Execution has a process technology laboratory, an analytical laboratory, and an experimental workshop. Therefore, R&D Execution, as a research and development centre with expertise in applied physics and chemical engineering, has the analytical laboratory, a laboratory for pilot plants, flow modelling testing, and workshops for test equipment. Both small-scale and full-scale technologies, systems, and products are tested. The project teams use the laboratories for tests, validation, and verification.

The R&D works begins with the design of a pilot. Next the Technical Leads talk to the workshop employees about the estimated time needed to build the pilot and about who will do the work. The workshop produces the metal plate and other items needed for the pilot. Together, the workshop employees and the laboratory personnel use resources in the development projects. A Technical Lead commented about the laboratory and the support people in the development projects:

It is worth its weight in gold to have the [laboratory and] workshop downstairs! It is easy to work with those who work downstairs and who have done the same things before. They know and understand it.

However, ideally, the project teams would like to run tests at customer sites. A Program Manager explained:

A common question is: Can it be tested somewhere else […]? [The answer is] depends on what we are supposed to do. Yes, this is completely new. Now we learn if it even works at the lab-scale first. […] Or we could say that this [project] has come far enough. Let’s build a pilot.
Tests are essential. The kind of test depends on the desired project outcome. For example, for a new project, the project team begins with tests in the laboratory before building a pilot at the customer site.

However, not all development projects require tests in the laboratory or at customer sites. Sometimes computer simulation models are sufficient. A Program Manager explained:

It is so very, very different how projects look. As I said, we have several projects where you just do computer simulations. You then rely much on CFD. [...] Then you can do projects that involve only creating a computer programme for a certain thing [...] you might want to make it smoother for when it is time for you to make an offer and to develop a computer programme for it.

Software programmes are also used in projects. Computerised Fluid Dynamics (CFD) is software that uses turbulence models to calculate different fluids. Engineers mainly use this software (that can be used for different mediums such as gases and water) at R&D Execution for flows. The software is much used in the projects and is considered an important tool for the development projects as well as for customer projects. A Process Engineer described the importance of the software:

Here, we use it primarily for gas, but it can be used for water as well. [...] 90% of the cases are about calculating currents in the various components that we have. It is important [...]. All the equipment we have is very dependent on flows. So it is very important.

Often the CFD and pilot run concurrently. A pilot, which is a downscaling of an entire plant, is built to provide insight on a function, such as a separation rate. CFD is used to explore flows and to check drops in pressure. CFD can then be applied at that scale or at full size.
6.2.3 Research and Development Management

R&D Execution’s strategy is to hold its resources (e.g., laboratories and employees) within the organisation. This gives them the possibility to learn, develop knowledge, and push technology into the market through the customer projects. The Local Manager explained the reasoning behind this strategy:

I think it is partly a historical factor. It is bred in our spirit in some way. But I also believe you can see great value in the learning process in technology development. I also think that you see great value in having in-house resources [engineers] who have worked with development. Because of their strong driving force, it [technology] can be implemented later in commercial projects. [People] can ensure that it is received correctly, appreciated in the right way, and implemented properly in the next step of commercial technology. That you have this technology knowledge is important in the R&D process, not only when developing new products but also when developing skills, which is not possible to summarise in technical reports or drawings or calculations. [...] I don’t think we are unique in that aspect; however, I think we are at the far edge of the scale. We do much ourselves while other industries outsource more.

Strategy planning and budgeting begin in the Autumn of each year. A meeting of representatives from marketing, sales, technology, and engineering and others from different parts of the firm is held. The Local Manager described these meetings:

Basically the process proceeds by gathering people [...] It is like a multi-functional workshop with people [...] We have a parallel organisation called Technology that owns the technology and the manuals, that ultimately signs the types of function guarantees we provide, that decides on the kind of technology we should select for a specific project, and so on. They are represented. We have representatives from the marketing side, representatives from the sales side,
and from engineering, and project execution. We usually invite people from nearby service organisations, for example, from the control and automation side.

This meeting is a multi-functional meeting where product strategies, marketing plans, and technology strategies are discussed. The representatives also discuss development ideas that have been presented during the year. The meeting results in a list of potential R&D projects. In the next step, there is a discussion on how these ideas can be realised in development projects. Then, as the list is refined, a project plan is created that describes in general terms what is to be implemented and what it is to be achieved. There is also consideration of the business effect of the projects, including return of the investments. Because the R&D budget is limited, the project must be prioritised using sales, marketing, technology, and engineering information. The Local Manager explained:

Everyone is involved in one way or another, either by votes or giving input. For each product, we have a product community with people from all these different functions. The prioritisation takes place within the product areas. Then you put together all this and look at what is available in the R&D budget. It is a budget process like other budget processes. We don’t know exactly how much we have in the R&D funds that we are able to get from the business. But it depends on how good the development projects are. If we have many good projects that we think will provide a quick return, the R&D budget can increase. By having well-prepared project proposals and well-presented cases, the chance of getting the R&D budget improves. But somewhere in the background there must be a reasonable relationship between how much money the business brings in and how much can be reinvested in R&D. It sounds like normal business. But we can influence the size of the budget by having good project proposals.

There is some flexibility as far as the project proposals and the budget limitations. Are the resources available? The Local Manager explained:
Then the next question is: How should we handle this? Then you start looking at the resource supply and the supply of skills. Do we have enough resources? Do we have the right resources? Are there areas of expertise that we lack, and so on? You can say that we have a strong tradition in R&D to do everything in-house. We do a large part of the work ourselves. But there are obvious areas where we cooperate with universities and perhaps consulting firms. [...].

The budget is finalised at the beginning of the year. Thereafter, the projects are decided on that will be carried out in next budget year that begins a couple months into the New Year.

A number of changes at Alstom Power have occurred recently. One change involves improvements in the generation of potential R&D ideas. One new feature is a meeting where representatives from different parts of Alstom Power discuss future ideas. This meeting permits brainstorming of new ideas for future potential development projects. A Program Manager described an ideas meeting that took place in 2009:

People gathered in one place. There were people from marketing and sales. There were technicians, and, yes, there were many. [...] and even the research engineers from R&D Execution attended.

The Technical Manager also commented on the meeting:

I think there were 45 people last year at the meeting. [...] Input could come in every possible way. [...].

After the first meeting of this kind in 2009, the decision was to make the idea retrieval meetings an annual event lasting two or three days. A Program Manager described the 2009 meeting:

There were presentations. The marketing people spoke about expectations in the market, and the sales people gave presentations. We did also. We talked about the kinds of development projects we were
working on […] we had a minor brainstorming session before [the meeting] where we tried to develop some new ideas that we also mentioned in our presentation – possible stuff to work on.

During the presentations at the 2009 meeting, the participants submitted written suggestions, which were then posted on a wall and sorted by area in the search for clusters and intersections. Although not all employees could attend the meeting, they could still submit their ideas. For example, R&D Execution had a pre-workshop before the 2009 meeting for this purpose.

Power Innovation is another channel for submitting ideas for potential development projects. Power Innovation is a web-based tool on Alstom Power’s intranet that is available to employees. Employees can use this tool to submit ideas. The Technical Manager commented on Power Innovation:

It exists in many other ways. There is something called Power Innovation, a web-based tool. You can submit written improvement suggestions at any time.

Ideas submitted on Power Innovation are sent to committees for evaluation. A Program Manager explained:

There are elected persons who make evaluations and ratings. If there is something interesting, it will be addressed at one of the patent meetings.

These ideas are distributed to the Program Managers. Each Program Manager has an area of interest and is authorised to deal with ideas related to that area. The Program Managers sort, summarise, and transform the ideas into project proposals. They then evaluate and rank these proposals. The Technical Manager stated:

The Program Managers bring these ideas to a variety of projects. They are the people who drive the process […].

The Program Managers make project charts that become the working documents for the projects. These charts describe the projects and the estimates of needed resources and activities. Marketing Managers assist the Program Managers. After
the development budget is completed, the Program Managers review and prioritise the projects that the budget will support.

The four Program Managers then begin to work more intensively with the projects – planning, costing, resource allocation, and staffing. A Technical Lead assists each Program Manager. However, Technical Leads are not tied to specific products. They work with several different products within a certain application area (e.g., dry and wet desulphurization).

The Technical Leads support the project with technical expertise and also act as Project Leaders. For example, they conduct the tests and make sure there are sufficient resources for the projects. The Program Managers deal with the project budgets while the Technical Leads deal with the technical aspects and manage the work. The Technical Manager of the Technical Leads explained the Technical Leads’ dual role:

They have a number of projects in which they are technical Project Leaders. They also do technical work in the projects. So they do both.

A Program Manager commented:

It is expected that they [Technical Leads] will work in the projects as well. […] they can be the contact persons for the Program Managers for planning or for updating their plans and providing status information on progress, and so on.

A Technical Lead commented:

Technical Leads are in charge of the technical aspects – conducting the pilots and overseeing the test campaigns. […] linking resources and employees to these tasks and planning for them. The Program Managers are responsible for the comprehensive planning. We take care of the technical areas.

Alston Power Sweden may provide the Technical Leads although other Alston Power units in other countries may as well. The Technical Manager is usually elected in February. The Program Managers and the Technical Leads plan the

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projects and form the project teams. A Technical Lead described this cooperation:

We list all employees in the departments. You know who has worked with what and what they have suggested […] that this resource can work with this product. With the NID, for example, we have people who have worked a lot with NID and who want to work a lot with NID, which is a related resource to that area. When it comes to minor problems, you solve them. If you need a laboratory for laboratory tests, we talk to those in the laboratory or with the head of the laboratory, and then schedule these resources.

The actual work in the projects begins in March and the beginning of April. The financial resources have been allocated to the projects, and it is known which resources and activities are needed. The projects begin with a kick-off where project teams discuss their projects and the desired outcomes. A Technical Lead described a kick-off:

The project begins with a kick-off that takes place pretty early in the year. It allows you to get commitments from everyone – from R&D and marketing as well as from other parts of the organisation that can provide feedback. We want to ensure that the project is profitable rather early. After this kick-off, the project is underway. Fairly soon you are in the first stage [of the process].

The development projects follow a structured R&D process consisting of a number of stages and gates. A project must be approved at a gate before it can continue to the next stage. There are six gates. A review committee composed of upper management from Alstom Power approves the movement of projects forward.

At the first gate, consideration is given to market trends and needs. Will the project result in a product that meets overall market requirements? Are resources and money available? Is the risk justified? A Program Manager described this gate.
[At this gate] the marketing side has been involved and has made a business case that the market demands this, and it is justified.

Specifications are created at the next gate. Here goals are specified and the customer demands are defined in metrics. A Program Manager stated:

This is when you set the goal on where you want to go. For example, in terms of efficiency, cost reduction, pressure loss, – all related to what you should try to achieve. We are trying to put some numbers on the stuff.

At the next gate, a determination is made to see if the evaluation of the concepts has been conducted properly and if the chosen concept is the best concept that will meet the product specifications. Resources, processes, and risk are evaluated. A Program Manager explained:

You then present the concepts. This refers to how to achieve your goals, one can say. As in our case […], we test all concepts in our lab pilot and try to evaluate them relative to one another and so on. We choose the best concept.

At the next gate, the design choice is evaluated to determine if the completed design satisfies the product specifications on a guaranteed basis. This requires reviewing the approved design with a focus on risk reduction (i.e., using known technology to minimise risk). It also requires determining whether the design is better and cheaper than the previous designs.

The project does not move to the next gate until there has been a sale or a pilot has been built. This involves collecting data from actual conditions and determining whether the process works as it is supposed to and if the pressure is correct.

When the projects approach the end of their development process, the Technical Leads prepare for the handover. The Technical Leads (or someone else in the project) hand over the design manuals that guide the design that is the result of the project. These design manuals are stored in a database. At this gate, customers are invited to offer suggestions for the product or application at a presentation.
Minor changes are explained in conference calls and emails. A Technical Lead explained:

We talk with the different sites so they can see and so we can explain how it works. But it is still carried out with the approval of the Product Engineering Management.

At the end of the processes there are limited releases. The Technical Leads want to learn if the processes work as they should. When the review committee approves the processes, there is a full release. Then begins the last phase when operations are checked to see if they satisfy the guarantees and have successfully passed the warrantee period. A Program Manager commented:

When you have sold a plant, you check it to find out if it really is as good as you have promised, if it is working as you thought, and if it matches your own models.

6.3 The Andritz Group

The Andritz Group is a global market leader in customised plants, systems, and services for the hydropower, pulp and paper, steel, and other specialized industries (solid/liquid separation, feed and biofuel). Certus Betelliguns-Gmbh, which owns the Group, is in Graz, Austria, and has approximately 13,400 employees worldwide. The group also has 35 service and production facilities and 120 affiliates around the world.

The Group focuses on five business areas: Hydro, Pulp & Paper, Metals, Environment & Process, and Feed & Biofuel. The Andritz Hydro business area is a global supplier of turnkey electromechanical equipment and services for hydro power plants; the product range also includes pumps for the pulp and paper industry and space technology components (e.g., for the European ARIANE rocket launcher programme). Andritz Pulp & Paper, the largest business area in the Group, provides technology and services for the production of nearly all grades of pulp used in the manufacture of paper, board, and fibreboard. The firm also produces specialized machines for the manufacture of tissues.
Andritz Metals develops, manufactures, and installs plants for the production of cold-rolled and hot-rolled, surface-finished carbon steel, high-grade steel, and non-ferrous metal strips. This includes plants used for the regeneration of pickling acids and for metal oxides. In addition, the area builds plants for punching and metal forming.

Andritz Environment & Process has a comprehensive range of technologies, products, and services for mechanical and thermal solid/liquid separation for municipalities and major industries (e.g., mining and steel).

Andritz Feed & Biofuel supplies systems and machines for industrial production of conventional mixed animal feed and high-quality, special animal feed. (Andritz Group, Annual Report, 2010)

The Andritz Group focuses on long-term and sustained growth, particularly in rapidly growing areas such as renewable energy sources, stainless steel, and special paper grades. The Group’s overall strategic goal is to consolidate and extend its market position. In its focus on R&D activities, the Group strives to be the technologically preferred supplier.

[…] the main goal is to develop customized technologies that enhance productivity of customers’ plants, minimize operating costs, and maximize energy efficiency and environmental protection. (Andritz Group, Annual Report, 2009, p. 2)

6.3.1 Business Areas and Performance

Andritz AB is a part of the Andritz Group. In December 2002, Andritz AB acquired the ABB Fläkt dryer division from ABB. The division was then called Andritz Fiber Drying. This meant that Andritz Fiber Drying had control of FI’s industrial drying activities.

At the beginning of 2008, Andritz Fiber Drying became part of Swedish Andritz AB. Andritz AB has about 320 employees in Sweden, a number of branches, and three subsidiaries (i.e., Östersund, Kristinehamn, and Vallentuna). The firm has locations in Örnsköldsvik, Hedemora, Stockholm, Karlstad, Kristinehamn, Nålden, Vallentuna, and Växjö.
The main products in Sweden are machines for the pulp and paper industry, equipment and services for hydropower, and grinding machines for steel production. The global centre for machine grinding of rolls for the steel industry is in Vallentuna. The technical centre for laundry presses is in Karlstad. The firm’s service centres, which include chemical and mechanical pulp and water turbines, are in Örnsköldsvik, Hedemora, Stockholm, Karlstad, Kristinehamn, and Nälden.

Andritz AB in Växjö is a global Technical Centre for the design and implementation of drying plants for pulp and biofuel. This global Technical Centre is an R&D facility that focuses on R&D in thermal drying and aerodynamics. The Technical Centre conducts both basic R&D and new technology R&D.

The major areas of the Technical Centre are development of drying processes for pulp, paper, and biomass, as well as heat recovery equipment for industrial applications. Drying is conducted for sheet drying, pneumatic flash drying, and fluid bed drying. Aerodynamic optimisation of equipment is an important area.

6.3.2 Research and Development Organisation and Resources
Around 60 people are employed at the Technical Centre in Andritz AB in Växjö. However, the number of people can vary, depending on the workload. When the workload increases, consultants are hired to reduce the work pressure. Because the number of consultants varies from 0 to 50, the total number of people employed at any particular time ranges from 60 to 110. The Technical Centre has six departments: Service, Capital Sales, Project Management, Mechanical Engineering, Process Engineering, and Technology. See Figure 14.
Each department has a manager in charge of the employees and tasks. Because the departments have different missions, they are involved in different types of projects (i.e., customer projects and development projects).

*Service* serves customer plants. This department works with installed plants.

*Capital Sales* deals with customer inquiries. Thus, the department creates and presents offers to customers.

*Project Management* focuses on customer projects. This department is comprised of people who work as Project Leaders and are responsible for the execution and delivery of customer projects.

*Process Engineering* handles the dimensions of the dryers, which means that the department sketches dryer size. They calculate the required length and width of the dryers according to the customers’ requirements. The mechanical engineers assist when the sites start up to help ensure that all processes are working as planned.

*Mechanical Engineering* focuses on the layout drawings. The department handles construction layouts (e.g., calculations for the precise numbers of screws, screw nuts, and bolts). The mechanical engineers must ensure that the dryers are correctly constructed.
Technology is only involved with development projects: research, product management, and patents.

Capital Sales, Services, and Process Engineering each employ six people. Mechanical Engineering employs 15-20 people.

There are five support functions: Controlling, Procurement, Human Resources (HR), Information Technology (IT), and Quality. Controlling, Information Technology, and Procurement each have two employees. Quality has three to four employees.

There are two types of projects at the Technical Centre: customer projects and development projects. Customer projects, which are mainly based on inquiries from customers, are only pursued when customers have accepted the Technical Centre’s offer. Development projects focus on R&D for improvements to existing product and processes (e.g., to enhance their productivity, minimise their operation costs, or maximise their energy) and R&D for new product and processes.

Customer projects begin when customers make inquiries. Capital Sales are involved in customer projects because this department receives customer orders. Development projects begin when Technology approves an R&D idea. Despite these differences in initiation, both project types pass through similar work steps. A Process Engineer explained:

Actually, it is the execution that is similar. Otherwise, nothing is equal. The execution is to pick key people from each function and create a project team. The project team then runs the project together with its Project Leader. In this way, it is the same work progression as in normal projects.

Development projects are the foundation of customer projects. For example, a development project may also be initiated by a customer inquiry, leading to the situation in which a development project and a customer project are intertwined. A Process Engineer described this integration:

It was not long ago that we received an order for a large machine that we had never been near before. We then executed the development project while the customer project was on-going. […]

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Although, the Technical Centre, deals with both project types, it has relatively few employees. The number of employees is a complex problem for managers. The Technical Centre is a technology department focused on R&D, but it is not an R&D function with its own dedicated R&D resources. A Process Engineer commented:

[…] I have worked here in various projects. And, as you know, since you talked to the others, we have quite a few employees. You may say that we work very flat. We are all working everywhere, and there is always something to do. You simply jump in. We have no pure R&D department, even if the Technology Department is responsible for development. But it operates projects where each Project Leader gives birth to ideas or takes care of someone else’s ideas. We start a project, run it with a project team, and then work towards the objective.

It is typical that part of the development work in projects involves testing of new machines and testing of improvements on existing machines and equipment. The purpose of the many tests is to acquire insight on operational parameters (e.g., flow patterns when heat and energy are transferred). The Project Leader is responsible for deciding (based on the desired project outcome) if a project requires test runs for validation or not. Generally, the engineers want to conduct these tests as pilot-scale studies at customer sites. The Design Manager explained the steps:

Once you have completed this conceptual phase, so to speak, and you have made the 3D model and the process evaluation pilot plans, you do some tests in the field before making the full-scale, detailed groundwork. You remove equipment on an existing machine and attach new equipment to find out how it works in the field. After that, you do the full-scale, detailed groundwork.

However, the engineers cannot always conduct tests in the field. They may have to conduct the tests in the laboratory. The most experienced engineers at the Technical Centre supervise these laboratory tests. The Design Manager stated:
When you cannot make a validation in the field, then the best you can do is to do a laboratory test.

The Technical Centre, which does not own a laboratory, must rent part of Alstom Power’s laboratory. This is the same laboratory that FI used to perform tests for the pulp and paper area. A Process Engineer explained:

We rent some space in the great hall where they are. We have an area there that we rent for a monthly fee.

The rented laboratory is near Andritz AB in Växjö. Management at the Technical Centre thinks the laboratory is essential. Renting Alstom Power’s laboratory is a practical and reasonably cost-efficient solution.

6.3.3 Research and Development Management

Andritz Pulp and Paper sets strategy annually. The strategy time frame begins at the end of the summer and ends mid-summer of the next year. Thus, the firm look to the future when creating strategy for firm growth and development.

Management at the Technical Centre strives to make market predictions in the formulation of product strategy. This strategy is presented to the Pulp and Paper division. A discussion at the division level begins on how to develop the overall business strategy. Data from the Technical Centre are presented. The result of this discussion is a development plan for projects and activities for the next year/years. Work on strategy continues for several months.

Management at the Technical Centre has recently changed how they work with strategy. Management now focus more on formulating well-defined product strategies for products (e.g., goals about what they want to do and why). The Technology Manager describes the strategy work:

What we have introduced this year is that we create our own clear product strategy. [...] It is to give input into the overall strategy. In this traditional Pulp and Paper [division], which we are in, you look back and project forward so you can see quite clearly what is going to happen. We are more focused on finding innovations that will enable us to take a step […]

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to take a step forward. The industry is moving towards building larger and larger plants. If you look at our development, it is much more about moving boundaries.

Management at the Technical Centre holds a joint division meeting before summer to look at the strategy for the entire division. At the division level, there are many discussions about the market. At the joint meetings the discussion usually involves how to develop the division’s process/product portfolio/programmes in the Group. The Andritz Group has recently begun to change from a product focus to a more process focus; this change requires closer cooperation and communication within the division. Market changes in the industry prompted this new focus. The Technology Manager explained:

The industry was much segmented for each product. Today, the industry is much more about delivering the big picture. It’s the same approach that we take on this side now. […] On the international markets, we have traditionally delivered a product. [Now] we deliver a unit – we are supplying a process solution. We and the rest of our group are making the journey today where we look at the big picture. A lot of the work we do today is the integration of the various components […] it is a process solution we are looking at. At the same time, of course, we must also improve our own product.

The Technical Centre is, therefore, a supplier of products that are part of the overall process solution from the Pulp and Paper division. However, the strategy work at the Technical Centre still revolves around the products. As the global technical centre for the Andritz Group, the Technical Centre is responsible for the technology and initiatives in dialogue with senior management on what needs to be developed. The Technology Manager clarified:

We take the initiative. There is rarely someone who comes and tells us: ‘Develop this’. The initiative may come from the existing product lines: ‘Should we not do this together?’ It may be so. Such initiatives are very positive. But at a global product centre – like our organisation – I expect that despite everything, we drive it. Otherwise we are not the product centre we should be.
The Technical Centre finances its development projects from a share of the Group’s annual profit. The amount depends on the budget decisions in the strategy work. The decisions are made at division level by reviewing different development ideas and analysing their costs. The Technology Manager, Product Manager, and the Local Manager of the Technical Centre estimate the cost of their various projects.

In 2009, the major focus of the R&D activities in Pulp & Paper was helping customers achieve sustainable production with higher capacities as well as higher energy efficiency. This was the same focus of the entire business area. The Technical Centre provided some of the production system needed for a customer offer. The Design Manager explained:

Andritz Group is divided into business areas, and within each area there are various business lines [...] Andritz usually delivers a total package to the customer. [...] The customer sees Andritz as one unit. Växjö delivers a sub-set of the product.

Development activities at the Technical Centre are essentially market-driven. This means customers are behind most development initiatives. Personnel with close customer contacts forward customer information to the Technical Centre. Co-workers may also make suggestions. Their suggestions usually involve how to improve something. The Design Manager explained the difference between market-driven and internal-driven ideas:

A lot is driven by the market [...]. The market demands things. We do not come up with the ideas. Of course, individuals can come up with improvements [...] but these are some minor changes, only to make something smarter.

The Technology Manager is responsible for summarising the potential ideas for development projects and for choosing the Project Leaders for development projects. Employees can apply for a development project by presenting a project plan to the Technology Manager who will then evaluate the idea and the project plan. A Process Engineer described the application process:
…] You may apply for a project. ‘I would like to pursue this project. How much will it cost?’ You have to make a presentation of the project. It may then be approved or not. [If it is approved], you can then run the project just as you want.

When a project is approved, the next step in the development process is to put together a project team. Often, the individual who has the idea, or someone from the same department, may be chosen as the Project Leader. In such cases, the Project Leader is naturally familiar with the project idea and understands the activities and tasks required to complete the project on time with the desired outcomes. The Design Manager described how the Project Leader is chosen:

He is elected. We have no specific people who just work as Project Leaders. Instead a person is chosen who best suits the mission. It may be a mechanical engineer, but it might as well be a process engineer or a manager, depending on who is best suited.

It is quite common that ideas for development projects originate in an engineer’s field. If that person is chosen as Project Leader, then the idea’s originator is committed to the project. A Process Engineer explained:

Usually, they [mechanical engineers] get their ideas in their field. I get very few ideas in their field because I am not familiar, for example, with the new angle iron. I’ve never built an angle iron (or any other component) so I do not know how to build one in a smarter way. It is the mechanical department that presents such ideas in that case.

After choosing the Project Leader, the project team is created. The team’s composition (engineers from different departments) depends on the project definition, which is made at the project’s inception. The Project Leader writes the project definition, the project specification, and the project goals as well as identifies the required resources. The resource procurement must be coordinated with the department heads.

The project team usually consists of process engineers, mechanical engineers, and automation engineers. The process engineers may be responsible for the development process. They study the capacity needed to make flow calculations, dimensioning, and more. The mechanical engineers are involved in drawing the
concepts in 3D where the detail engineering occurs. The automation engineers
are involved in the automation areas.

Once the project is approved, the Project Leader begins to form the project team.
He/she asks within the organisation about people who would be suitable for the
team. For example, the Project Leader can ask each department head for names
or may contact team candidates directly. Often some people are not available,
and other selections are required. The Project Leader’s team member selections
must also be approved. The Design Manager commented:

It is usually when we have a lot of orders that this becomes a prob-
lem. When we have a lot of orders, orders and development must
be prioritised. Those who are more experienced and more talented
are most sought-after. It becomes a struggle over them.

The Technical Centre follows a defined development process that originated in
the 1990s. This process has since been synchronised with the existing processes
of the Andritz Group in Austria that approves projects. In this process, repre-
sentatives of the Technical Centre describe the investments they wish to make.
It is a reconciliation process that involves budgetary considerations. The Design
Manager described the reconciliation:

[…] We check with them about how we think, how we see the fu-
ture, and what we need to focus on. It is reconciliation work. Usu-
ally it is not something drastic; we usually reach a consensus because
we think alike.

The project definition is the first step in the firm’s development operational pro-
cess. Prior to this step, the R&D programme, which including budget figures,
must be prepared. The budget is settled after the reconciliation between the
Technical Centre representatives and the Andritz Group management. The de-
velopment operational process description has six stages. Not all development
projects follow all the stages. The project’s specifications determine which stages
should be followed.

Thus, the projects start with a project definition. The project definition is a state-
ment about specific project requirements. The definition must include back-
ground and targets, including funding, the project team, and the needed re-
sources. The Design Manager explained:
Then the task is to write down what the goal is, what it is we should get out of it [the project], what is the method we will use. What is the background for wanting to do this? Who should be involved? Is there a project manager? How much money is needed? Are people available? This is time and resource planning.

This project specification describes the opportunities for patenting the results. The specification also describes the execution guidelines that the Project Leader will follow in commenting on project progress. When the project definition is completed and management approves the project specification, the process continues to the next stage – the pre-study.

For all larger project ideas, a pre-study is needed to explore the potential of the specific project. The pre-study is also conducted to identify major problems, critical areas, and other challenges. One example of an activity in the pre-study is benchmarking. The pre-study also involves the identification of critical project methods where resources are needed. The pre-study is used as the basis for a revised report that will be used later. The Design Manager explained this stage:

If it is a huge project, it usually starts with a pre-study. Then the project definition is the same as the pre-study. What you do next is to check the potential of the proposal. What are the critical methods that we must investigate? What kinds of resources are needed? We prepare a report document that includes descriptions of the potential outcome, the critical issues, and the likelihood we will finish the project [etc.].

In the third stage, the focus is the design and process development when the preliminary process and mechanical development takes place. Technical problems that appear at this stage are solved, and laboratory analysis is conducted to identify input for the work. Critical issues are resolved. The Design Manager described this stage:

The third step is to prepare the process of development by looking at the process-related [aspects]. Mastering the capacity needed. You have to make calculations with dimensions, flow calculations, and simulations.

When the design and process development is completed, the detail design work begins. This work, which consists of more detailed design of critical items, can
require more laboratory work to facilitate the detailed design or to increase the process knowledge or the material knowledge.

In the fifth stage the prototype is tested after finishing the necessary detailed design development. The prototype test can be conducted in either of two ways: in the laboratory or in the field. When the testing is completed, revisions are made based on the input from the prototyping and testing of the final design. In the sixth stage, which is the final stage, the presentation material is prepared. If necessary, the result is framed and then the product is completed.

6.4 The Fläkt Woods Group
In 1909, Maurice Woods founded Woods (incorporated in 1928 as M. W. Woods Ltd) in Colchester, England. The firm produced single-phase motors to suit the different voltages used at the time. Thirty-six years later, Maurice’s son, Geoffrey, became Managing Director. Soon thereafter the firm had 360 employees. In 1945, the General Electric Company (GEC), a major supplier to the military of electrical and engineering products, gained a controlling interest in the once privately held firm. In 1964, GEC acquired the remaining shares. In 1998, the firm changed its name to Woods Air Movement Limited. In 2000, Global Air Movement Holdings Limited, a firm formed by Compass Capital Partners, acquired the firm. (Flaktwoods.com, n.d-b)

In December 2001, ABB announced it had sold its air handling equipment business to Global Air Movement SARL for $225 million, including the Fläkt trademark. (ABB, then ASEA, had acquired the Fläkt Group in 1984.) ABB had decided to focus on power and automation technology products and systems and solutions for the utilities and other industries. As Global Air Movement had acquired Woods Air Movement in the previous year, the purchase of ABB’s air handling equipment business joined the two businesses: Fläkt and Woods Air Movement.

In February 2002, the Fläkt Woods Group was formed. Hannu Paitula, who had been head of ABB’s air handling equipment business, was the first CEO of the newly combined firm. Paitula described the acquisition:

We have a tremendous opportunity here to build a global leader, based on the Fläkt and Woods brands,
and the fact that the two businesses are highly complementary, both in terms of geography and technology. (ABB, Press Release, 2001, p.1)

After the merger, SEMCO, an American based firm, joined the group. At the time of this writing, Sagard controls the Fläkt Woods Group. Sagard is a Paris-based European private equity firm that invests in mid-market companies, primarily in France and Belgium. Sagard acquired the Fläkt Woods Group in 2007 from the British private-equity fund, Compass Partners.

“In recent years” said Fläkt Woods Chief Executive Officer Didier Forget, “we’ve successfully built a global provider of air handling and ventilation solutions, thanks to the talent of our employees and the confidence of our customers. Sagard’s acquisition offers us new opportunities to grow, further expand our geographic footprint, develop new technologies and consolidate our market segments”. (Sagard Private Partners, Press Release, 2007)

Fläkt Woods Group is a global provider of energy-efficient air solutions in air climate control for buildings and air movement for the infrastructure and industrial markets. The Group supplies products and systems for indoor air climate control in commercial buildings.

Fläkt Woods Group has three main businesses: Air Climate Solutions, Ventilation, and Global Infrastructure and Industry. Air Climate Solutions provides energy efficient products and systems in Europe, the United States, and Asia. It also provides air control solutions for specified buildings and for global applications. Ventilation provides a full range of products for ventilation and air climate control in commercial buildings in Europe. Global Infrastructure and Industry is a global provider of axial, centrifugal, and high pressure fans

Fläkt Woods Group, with corporate headquarters in Geneva, has local research activities in 95 countries with a direct presence with 80 agents in 30 countries, 26 factories in 20 countries in Europe, the United States, and Asia, and 3500 employees (2400 in Europe, 600 in Asia, and 500 in the United States). About 270 engineers, with expertise in aerodynamics, acoustics, air treatment, filtration, fluid dynamics, heat transfer, control and communication, energy efficiency, and air treatment work with R&D and customer projects. The Group has eight
R&D centres and test laboratories in Finland, Sweden, the United Kingdom, and France.

6.4.1 Business Areas and Performance
Fläkt Woods AB in Sweden has two areas: products and systems for indoor air climate control, and products and services for global infrastructures and industry. The headquarters for indoor air climate is in Stockholm; the headquarters for global infrastructures and industry business are in Växjö. The firm has twelve sale offices in Sweden. Four production units are in Jönköping, Enköping, Järna, and Aneby. Fläkt Woods Group operates research centres in Jönköping and Växjö.

Fläkt Woods AB in Växjö is the Centre of Excellence for large axial fans in the Fläkt Woods Group. The Centre is responsible for the development and sales of large axial fans. They sell these kinds of fans worldwide except in North America. They also sell small radial fans produced in the workshops in Växjö.

6.4.2 Research and Development Organisation and Resources
Fläkt Woods AB in Växjö has three main departments and two support functions. See Figure 15. The main departments are Project Engineering, Sales, and Commercial Operations. The support functions are Controlling and Quality.

![Organisation Chart - Fläkt Woods AB (Centre of Excellence for large axial fans) in Växjö](image)

*Sales* sells the fans. As they make offers to the customers, this department has the first contact with the customers. The employees in this department manage customer orders and contract negotiations.

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*Project Engineering* has two sub-departments. One sub-department, Technical Support, provides technical specialists and testing and commissioning personnel. The other sub-department, Project Engineering, employs design engineers who make drawings and calculations.

*Commercial Operations* manages customer projects and also provides Project Leaders for these projects. The Project Leaders plan the customer projects and time occupancy of assemblers, supervisors, and test facilities. The department also manages purchasing, logistics, and assembling.

Twenty-three employees work at Fläkt Woods AB in Växjö (the Centre). Technical Support and Project Engineering each employ five people. Sales employs three people, and Commercial Operations employs six people. Project Management employs four people. However, the number of people who work at the Centre increases when consultants are hired. The Centre does not have its own R&D department for product development. However, the three Technical Support people (from Project Engineering) also work with R&D. The Centre, which also lacks a laboratory, rents Alstom Power’s laboratory facilities.

The work at the Centre is organised by projects: customer projects and development projects. Although similar in some ways, the work in these projects is also different. Customer projects originate with customer inquiries and customer offers from Sales. Development projects originate in R&D ideas and are intended to increase efficiency, for example, of the fans. R&D focuses primarily on large axial fans.

The Centre has a fairly compressed organisation structure. The Technical Manager for customer projects, at present, is also the R&D Manager for development projects. Given the few employees, it is necessary to prioritise between customer projects and development projects when providing technical support. The R&D Manager explained this problem:

> You need to do some documentation before the order stage to get the order. There are some questions that the customer wants answered. There are designs that need to be made before you get the order – some assembly drawings. There is also fan choice. We need to choose the fan that we can offer. There may be a technician [an engineer], such as an aerodynamicist, involved in the fan choice. We choose the right fan for the customer, so to speak. We call this sales support. The major things that we [the department] are doing are
sales support, order design, and R&D. Those are the three things we are trying to juggle. Which to prioritise? We have, of course, our development projects for each year. But design gets the highest priority because it generates money. Without sales support, we have no chance of getting new orders.

Development projects are mostly about optimisation of the fans. The R&D Manager explained the focus:

It can be cost-cutting. That is what we most want to get – as much as possible – from the pressure and flow from our fans. We want to move the air as cheaply as possible.

In recent years, we have not had the resources for long-term, basic research. We have not have the ambition to conduct the basic research needed to obtain a revolutionary patent. We do not have the resources to make newer things.

Despite the problem of insufficient resources, the Centre still is interested in making changes and improvements to their fans and in the possibility of using the fans in other processes. The Centre tries to involve Sales in these efforts. Following a go-ahead decision for an idea, the actual development work begins. A Mechanical Engineer explained:

We have ideas, and then we discuss these ideas. One of the design engineers then visualises the idea as 3D in CAD. It is a model that we can look at together and think about. You may not begin to calculate at once when you start with such a development project. It may be more about sketching it, then evaluating it, and then discussing it before getting more specific. Then we start making calculations. In a customer project, we start directly with the calculations because we know how those projects are supposed to go forward. But development may take five different kinds of CAD models with slightly different variations. Then you select one of them. It is a bit different, and it involves a lot of discussion [...]. Then more people may enter. Purchase is included to make an assessment. Will it be cheaper than before, or will it be much more expensive? If more expensive, they say “no, no. We cannot sell this”.

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The mechanical engineers work closely with the design engineers in both development projects and customer projects. The design engineers usually begin with visualising the idea as 3D in a CAD programme. The mechanical engineer then imports this 3D model to a calculation software in order calculate the abrasion resistance, tension, etc. The process engineers focus on increasing the fan performance. They begin their work with theoretical calculations on how the process improvement works in reality. A Process Engineer described the work:

We work with something that we have set for ourselves in a project… Take this fan that has to produce 10% more flow or 10% more pressure. […] I will then make the necessary calculations […]

A software programme is used to make calculations of fan performance. The programme was developed based on computational software that can, to some extent, calculate the design of fan blades. Previously, the process engineers could not present a chart of theoretical fan performance. To develop a new fan series, they had to run many tests, leading to expensive development projects. Therefore, the decision was to develop the programme now used to calculate the entire process from the inlet to the outlet of multi-stage fans with a rotor and a stator. Although the software is reliable and effective, sometimes the projects require more advanced applications for the theoretical calculations.

If necessary, the process engineers contact the outside consultants who have more advanced calculation software. A Process Engineer describes hiring of the consultants:

[A process engineer] works with development of our largest fan, our power plant fan. Then we make theoretical calculations. Thinking and then calculating. For this software, we have consultants in Gothenburg who make calculations for us. We have found a good firm in Gothenburg. The software we have is a very fast programme and gives quick results, but there is even more advanced software that is very hard to develop. We have no such programme. […] To use such software, you need to sit and calculate all the time, and we do not have a need for it. However, sometimes it becomes necessary, and then we order these calculations from the consulting firm.

After the theoretical calculations are completed, laboratory tests are made to verify that the fan, as designed by the theoretical calculations, works in practice. The same Process Engineer explained:
 [...] first [the process engineer] calculates with our own programme. Then he makes a real CFD calculation, as it is called. In the next step, [he] tests the same thing in the laboratory to verify that we have developed it right.

The large axial fans, which cannot be tested in full-scale models, are tested in small-scale models. Based on size, a major difference is at the ratio of approximately 1:5. For aerodynamics it is possible to scale the size, but scaling does not work with the mechanical calculations.

The Centre hires laboratory facilities from Alstom Power for its various performance tests. Test engineers from the Centre take responsibility for these tests runs. A Test Engineer explains the development process:

Development is, what can I say…? It is a long process. You know a month in advance that there is something going on. It is talked about and things are ordered. Eventually, everything comes here, more or less finished. Sometimes you build it here with people who are borrowed or with our own employees. [...] The development is aimed at achieving better performance. It is a good thing. That is why you do development. They ask for greater flow, higher pressure, better efficiency, lower noise levels, and the ability to withstand higher temperatures. There will always be more requirements. Regulatory requirements are tightening. It is moving in that direction.

When the tests have been made, sales literature is prepared for the improved fan or the new fan series. This literature describes for example, the fan’s (or fans”) performance, effect, and noise levels.

6.4.3 Research and Development Management
Global Infrastructure and Industry (one of the three business areas of the Fläkt Woods Group) owns Fläkt Woods AB in Växjö (the Centre). Upper management in Geneva sets the strategy goals. The Fläkt Woods Group has a Technical Manager for the entire Global Infrastructure and Industry area. This manager, whose title is Senior Vice President of Technology, is responsible for long-term strategic planning and for tracking the firm’s competitors. The Technical Manager visits the Centre several times a year to have reconciliation meetings with the R&D
Manager and the Local Manager. At these meetings they discuss development projects for next year. The Local Manager described these meetings:

The R&D begins when the R&D Manager and the Senior Vice President of Technology meet with me and discuss which steps we should take next year to achieve the goals we have set.

Decisions on next year’s development projects are based on market information the Technical Manager, R&D Manager, and Local Manager provide. Development projects at the Centre are market-driven because many development project ideas originate in market demand. The R&D Manager stated:

The market basically initiates [Development projects].

To collect market data and ideas for potential development projects, the R&D manager works closely with sales personnel, agents, and engineers. The focus is on getting competitive products at competitive prices. The R&D Manager described these ideas:

It may be related to cost-cutting. It may also be related to getting as much pressure and flow from the fans as we can. We need to move and lift [air] as cheaply as possible. Much is about optimisation of the product. If, for example, we can increase our efficiency a few percentage points, we can be very competitive. If, with the same fan size, we can increase the pressure and flow rate by 10-19 percentage points we can choose a smaller fan with the same application. Our competitors will have to choose a bigger fan. Then our fans will be cheaper. Thus, much is linked to the type of optimisation, improving efficiency, and increases in the pressure and flow for existing products.

The R&D Manager summarises the development project ideas and then presents them to the Technical Manager. The Technical Manager evaluates the ideas; some are accepted, some are rejected. For the accepted ideas, the R&D Manager creates a rough budget based on estimations of the amount of resources required
for completing the projects. This ‘rough’ budget, which is usually ready in October, contains the cost details of the planned activities for each project. The Local Manager explained:

[…] you have to go in and say that it will take this many hours for this person, and it will take this many for this [other] person. We will need this part, and we will make these lab tests.

At year-end, the budget is set for the development projects. As the Centre of Excellence for large axial fans, the Centre owns the products and is also responsible for some R&D expenses. The Local Manager described the situation:

When you’re a Centre of Excellence, like we are for our product, [a certain] percentage of development costs always end up in the Centre of Excellence. This is according to the rules at Fläkt Woods [Group], no matter which Centre of Excellence. A certain percentage, you always eat [carry]. The remaining costs are allocated to the turnover in a third party relationship.

The R&D Manager compares planned expenditures in the development projects on a monthly basis to actual expenditures. These comparisons are sent to the Technical Manager.

During the year, the R&D Manager, the Local Manager, and the Technical Manager meet to discuss the progress of each development project. They discuss the resources used in the projects, their estimated costs to complete, their competitive strength, and their financial return. The conclusion of these discussions is a decision on whether to continue or halt the projects.

Every year the R&D Manager and the Local Manager study the market to learn of new market demands. They report on these demands as inspiration for potential development projects. They conduct this work with Technical Manager who is in charge of strategy for Global Infrastructure and Industry. The R&D Manager, the Local Manager, and the Technical Manager usually meet at year-end to discuss next year’s R&D, including the ideas the R&D Manager has summarised. The R&D Manager described how ideas are collected:
I usually try to make a list of items when I come across things that I think we should go ahead with in research and development. Usually they are improvements rather than entirely new products under consideration. I make a list, and at the end of the year I compile the list to try to identify a number of points. If we do this, we can achieve this and this.

The list of different project ideas is also presented to the Fläkt Woods Group in the United States and to the management team at the Centre. Some of the Centre’s customer projects are now in the United States. Evaluations and comments from sales personnel on the competition in the United States are important.

The engineers may also contribute with their ideas. The R&D Manager stated:

There have been some ideas [from an engineer] who has worked with development projects during the year. He said, “We should move forward on this”. If we can improve and optimise this work, there is a potential for our product. We also receive comments from the sales people when they think we should invest [in projects] to give them a more competitive product.

Therefore, ideas about potential new products or improvements to products may arise anywhere in the organisation. Such ideas are communicated to the R&D manager when appropriate. A Process Engineer described how ideas are communicated:

This is a very small business. We see each other at the coffee break. Anyone can toss out any idea. However, usually we work with development. But it can also be the seller who comes and says that the customer thinks that we should do this and that. It can come from anyone in a very informal way.
6.5 Summary of the Case Studies

This chapter on the three firms provides the background for the analyses in Chapters 7 and 8. Similarities and differences are found among the three firms. See Figure 16.

Readers’ Guide: These names are in this section.

R&D Execution of Alstom Power Sweden = Alstom Power Växjö
Technical Centre of Andritz AB = Andritz Växjö
Centre of Excellence at Fläkt Woods AB = Fläkt Woods Växjö.

6.5.1 Responsibility Characteristics

As Figure 16 shows, both Andritz Växjö and Fläkt Woods Växjö have development projects and customer projects, although their focuses differ. Andritz Växjö balances the two project types and tries to maintain a certain level of R&D in development projects, Fläkt Woods Växjö focuses mainly on customer projects.

6.5.2 Organisational Characteristics

Alstom Power Växjö employs about 70 people Andritz Växjö employs about 60 people. Fläkt Woods Växjö employs about 23 employees.

Alstom Power Växjö has decentralised, functional groups consisting mainly of engineers with different backgrounds (e.g., mechanical and process). These engineers in R&D support the development activities. The in-house strategy means the firm owns its important resources and does not use outside consultants to any great extent.

Andritz Växjö and Fläkt Woods Växjö have specialised, decentralised functional groups. They do not have specific R&D groups. Instead, each has a group of engineers variously involved in both development projects and customer projects. The organisational structures of these two firms are more flexible than that of Alstom Power Växjö because they hire outside consultants as needed.

6.5.3 Product Characteristics

Alstom Power Växjö works with air pollution control equipment. They develop and sell advanced systems and products for flue gas cleaning to power plants and the power industry. Andritz Växjö focuses on developing products, managing projects, and selling services to the pulp and paper industry. Fläkt Woods Växjö
works with air movement for their global infrastructure and industry business, in particular with large axial fans.

The three firms specialise in providing products and services directly to other businesses (i.e., B2B situations). They take large orders that require long periods of time from sales offer to sales close.

The three firms are involved in air handling technology. They develop and offer products and systems of high complexity as far as structure, size, and shape. Scientific analysis with accurate data input and careful calculations are required.

6.5.4 R&D Characteristics
R&D activities at the three firms are project-based and temporary, with defined beginnings and ends. Each project is unique with a specific goal and a specific set of activities designed to realise this goal. These activities are managed using project on-time goals and project on-budget results in accordance with market demand, regulations, and laws.

A team of employees at each firm typically is assigned to a project. The project team members have different backgrounds and expertise. Each team has a Project Leader (i.e., the Project Manager) in charge of the team and the project. The Project Leader’s responsibilities include tracking costs and resource use and reporting variances from pre-determined plans. The Project Leaders also created contingency plans for instances when there are cost over-runs, schedule delays, and specification changes. Moreover, the Project Leader prepares a draft of the roles and responsibilities needed for the projects. These drafts are used in discussions of resource needs with the functional managers and potential team members.

Alstom Power Växjö has two Project Leaders (Andritz Växjö and Fläkt Woods Växjö each have one Project Leader). One Project Leader is the project manager who is responsible for the day-to-day work in the projects; the other Project Leader is responsible for the technical direction of the projects. This means ensuring the technical progress of the projects and helping project managers to identify potential team members with relevant knowledge and expertise.

Project Leaders must create strong and results-oriented project teams. The Project Leaders at the three firms use their experience from previous project and managers’ feedback to identify effective team members. At Andritz Växjö and
Fläkt Woods Växjö, the team members on one project are shared with other projects. Unlike Alstom Power Växjö, the resources of these two firms are primarily for R&D. Therefore, they share resources among their projects.

6.5.4.1 R&D Process
The development projects at the three firms originate in various ways. Employees, customers, and sales personnel may suggest ideas. In many cases, these ideas are based in useful knowledge of the market. Ideas with good potential may lead to projects depending on the evaluations following their detailed presentations. When project ideas are approved, the R&D activities of detailed design, testing, and validation follow. Some project results (e.g., a product) are then produced and launched. However, some projects results are only used as preparation and documentation in other offerings.

The three firms prepare project goals. These goals take project scope, time, resources, costs, communications, risks, and schedules into consideration.

Although the three firms try to manage their projects as effectively and efficiently as possible, they deal with project performance differently. Both Alstom Power Växjö and Andritz Växjö have a defined and specified development process that is market-driven. The two firms divide their processes into pre-determined stages in which each stage consists of a set of certain activities. These activities must be completed before a review committee approves the advance to the next stage of the R&D process.

The review meetings used (such as the Go or Kill check points) are intended to control the progress of the projects consistent with their goals and to analyse their achievements so that opportunities for improvement can be identified. At Alstom Power Växjö, the review committee is composed of senior managers and firm-level R&D managers. The review committee at Andritz Växjö is composed of only firm-level R&D managers. At Fläkt Woods Växjö, senior managers and a firm-level managers review development projects, but the firm does not have a specific development process.

6.5.5 R&D Resources Characteristics
The analysis of the three firms reveals that each firm has many resources. These resources include various tangible resources such as cash, machinery and equipment, test facilities, office buildings, workshops and warehouses. The firms also
have various intangible resources such as knowledge, goodwill, and employee skills, experience, and know-how.

None of the three firms owns the exact same resources. However, their R&D resources are quite similar. Although there are differences among the employees as far as degrees and university backgrounds, each firm employs a group of people with similar experiences, skills, and education.

In particular, the three firms employ the same kind of engineers – automation engineers, process engineers, and mechanical engineers. This similarity is no doubt attributable to the fact that the three firms are engaged with air handling technology. Only Alstom Power Växjö employs chemical engineers. The firm requires such chemical engineers for their products and processes that are based in chemical reactions and solutions.

The three firms are also similar as far as their test facilities, office buildings, workshops, and warehouses. For instance, although they use different test equipment (because of different kinds of tests conducted), they conduct pilot tests and validations at the same test facilities/workshops. The three firms also have modern, open landscape offices. Andritz Växjö and Fläkt Woods Växjö have offices in the same building. Alstom Power Växjö’s offices are adjacent to its test facility.

The three firms use the same type of information technology. They use design and simulation information technology programmes such as 3D CAD solutions and fluid flow, heat transfer, and fluid forces programmes. They use this technology to validate designs when they make critical technical decisions.

6.6 Chapter Summary

The Chapter describes each of the three firms of this study in detail (histories, organisation structure, employees, R&D focus, resources, etc.) This background information is useful for the analyses in Chapters 7 and 8. The firms conduct R&D activities in different business areas. Yet, despite obvious differences, there are also similarities in how they conduct their operations. See Figure 16.
<table>
<thead>
<tr>
<th>Responsibility Characteristics</th>
<th>Alstom Power Växjö</th>
<th>Andriz Växjö</th>
<th>Fläkt Woods Växjö</th>
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<tbody>
<tr>
<td><strong>Executes development project, but supports also customer projects with expertise. (Customer projects are executed in another organisation)</strong></td>
<td>Executes both development and customer projects. The focus is on creating a balance between them.</td>
<td>Executes both development and customer projects. The focus is primarily on customer projects.</td>
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<tr>
<td><strong>Organisation Characteristics</strong></td>
<td>70 persons work at the R&amp;D firm.</td>
<td>60 persons work at the R&amp;D firm.</td>
<td>23 persons work at the R&amp;D firm.</td>
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<td></td>
<td>The firm uses consultants at a minimal level.</td>
<td>The firm changes the size of the organisation by using consultants. This is done when the number of customer projects increases.</td>
<td>The firm changes the size of the organisation by using consultants. This is done when the number of customer projects increases.</td>
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<td></td>
<td>An R&amp;D organisation. R&amp;D is separated from Sales.</td>
<td>No R&amp;D function. R&amp;D is integrated with Sales. They are performed in the same organisation.</td>
<td>No R&amp;D function. R&amp;D is integrated with Sales. They are performed in the same organisation.</td>
</tr>
<tr>
<td><strong>Product Characteristics</strong></td>
<td>Systems and products for air pollution control.</td>
<td>Products and service for drying pulp and biofuel.</td>
<td>Product and service for infrastructure and industry. (Large axial fans)</td>
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<td>R&amp;D executed as development projects.</td>
<td>R&amp;D executed as development projects.</td>
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<td>Cross-functional teams (i.e., engineers with key knowledge).</td>
<td>Cross-functional teams (i.e., engineers with key knowledge).</td>
<td>Cross-functional teams (i.e., engineers with key knowledge).</td>
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<td>Appointed program managers.</td>
<td>Appointed project leaders.</td>
<td>Appointed project leaders.</td>
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<td>Appointed technical leads.</td>
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<tr>
<td>Program manager is appointed by management in a separated organisation.</td>
<td>No specific development Project Leaders. They choose a person who, they think has the relevant knowledge and experience.</td>
<td>No specific development Project Leaders. They choose a person who they think has the relevant knowledge and experience.</td>
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<tr>
<td>Technical lead belongs to the R&amp;D organisation. Technical lead is selected by program manager together with the technical manager.</td>
<td>Cross-functional team is selected by Program Manager and Technical Lead and managers.</td>
<td>Cross-functional team is selected by Project leaders together with mangers of the different departments.</td>
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<tr>
<td>Cross-functional team is selected by Program Manager and Technical Lead and managers.</td>
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<tr>
<td>Focuses on ownership of important R&amp;D resources held within the organisation. It is called &quot;in-house strategy&quot;</td>
<td>Owns the R&amp;D resources, but hires consultants and rents a testing facility when as needed.</td>
<td>Owns the R&amp;D resources, but hires consultants and rents a testing facility when as needed.</td>
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<tr>
<td>R&amp;D Process Characteristics</td>
<td>R&amp;D Resources are shared between development projects. Occasionally, engineers support customer projects.</td>
<td>Resources are shared between development projects and customer projects.</td>
<td>Resources are shared between development projects and customer projects.</td>
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<td>Development process consists of 6 phases that are followed by gate reviews.</td>
<td>The development process consists of 7 phases that are followed by gate reviews</td>
<td>The gate reviews are conducted by a committee composed of management at firm level.</td>
<td>There is no development process model.</td>
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<td>The gate reviews are conducted by a review committee with representatives at senior management.</td>
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<td>Projects are reviewed at the senior level management and at firm level management.</td>
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<td>External bench marketing</td>
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<td>Innovation system for employees</td>
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<td>Project expenditure Budget.</td>
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<td>Time frames</td>
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Figure 16: Summary of the case studies
Chapter 7: STRATEGIC RESOURCES AND COMPLEMENTARY RESOURCES IN THREE CASES

This chapter analyses the three R&D firms’ resources and explores whether and how these resources provide competitive advantage. The analysis takes the Resource-based View (RBV) on strategic resources.

Each firm’s resources were identified and mapped using a within-case analysis of interview and archival data about the firms. Chapter 6 presented these data. See Figure 16 for a summary of these findings.

This chapter focuses on the resources used in the firms’ development processes. Barney’s (1991) VRIN framework is used for the analysis (see Chapter 2 for a discussion of this framework). According to the VRIN framework, a resource can provide competitive advantages if it is Valuable, Rare, Inimitable, and Non-substitutable.

7.1 Strategic Resources at the R&D firms

Researchers have identified a number of factors that contribute to the success of R&D firms (Cooper, 1979a, 1979b; Cooper & Kleinschmidt, 1987; Montoya-Weiss & Caltone, 1994; Brown & Eisenhardt, 1995; Griffin & Hauser, 1996; Hennard & Szymanski, 2001). Resources are one of these factors.

Previous studies show that the development of products and processes is highly dependent on the resources used. This within-case analysis of the three firms shows that their development of products and processes is no exception.

Previous studies on R&D and resources often report that resources are crucial in the development processes of firms as they compete in the market. However, according to some of the RBV literature, only those resources that have the VRIN attributes can be described as strategic resources that provide competitive
advantage (e.g., Barney, 1991; Grant, 1991; Peteraf, 1993; Amit & Schoemaker, 1993). R&D researchers who take the RBV argue that strategic resources enhance the ability of R&D firms to produce successful products (e.g., Brown & Eisenhardt, 1995; Verona, 1999; Krishnan & Ulrich, 2001). Such studies of R&D firms and their resources conclude it is important to identify these resources if we are to understand which resources contribute to the competitive advantage of R&D firms.

As the map of the firms’ development processes shows, the three firms use both tangible and intangible resources in their development projects (and customer projects). However, some of the mapped resources, which lack VRIN attributes, are categorised as complementary resources. This chapter analyses both strategic resources and complementary resources. The analysis is presented in the following sections: Technical Resources, Financial Resources, Human Resources, Relationship Resources, and Less Strategically Relevant Resources (i.e., Complementary Resources).

7.1.1 Technical Resources

Resources used in innovative and technical activities in the development process are important because they affect overall performance (Kandemir et al., 2006). The three firms have tangible resources such as machinery, equipment, test facilities, office buildings, workshops, and warehouses (see Grant, 1991; Wilk & Fensterseifer, 2003) that are fully owned or rented. The firms consider these key resources because their R&D activities require advanced engineering equipment for use in, among other things, product validation and compliance with industry and legal requirements.

When Alstom Power Växjö acquired the power segment from ABB, it also acquired FI’s Växjö laboratory. Alstom Power Växjö now uses this fully equipped process and analytical laboratory, plus its workshops, to support its innovative and technical activities.

The Local Manager at Alstom Power Växjö described the laboratory:

[The laboratory] is priceless and unique. We have a unique place to carry out development in this technology area, and we are very grateful for the tremendous foresight of the technology-driven managers at SF who invested in this business.
Without the laboratory, the firm could not conduct its advanced process and chemical tests. The laboratory also provides vital support for customer projects. It is essential for an R&D firm engaged in product and processes to have the capacity to conduct advanced tests and to demonstrate its technical expertise. The Head Manager of Alstom Power Växjö Sweden stated:

We always try to plan a tour of the lab. We often bring them [customers] there, and it is usually very positive. There is no laboratory like that anywhere else in the world. It’s worth going there.

The Technical Manager at Alstrom Power Växjo said:

When we are in the sales phase and in the project implementation phase, we invite customers to look around the laboratory. The fact is, the process industry is very capital intensive. Our customers invest a lot of money and are risk averse. They want to buy proven technology and they want it documented. It is incredibly hard to implement new technology in the process industry because the financial risks are so high. Thanks to our lab, we can do much of the work needed to reduce these technical risks and build trust in the technology we develop. With our pilots, we can show experimentally what will actually work. There is tremendous value in positioning the company from our customers’ perspective. We find it useful to build trust and relationship in many contexts.

Andritz Växjö also uses essential technical resources (e.g., offices, warehouses, a laboratory, and workshops). The firm rents laboratory space from Alstom Power Växjö. The laboratory allows the engineers to conduct various advanced technical tests. The Technology Manager at Andritz Växjö explained:

We make improvements – heavier and bigger changes – and then we test the components. We do a lot of tests of fans, for example. We test steam batteries [svångbatterier]. We test when we build a number of smaller things that we measure. […] We test the critical parts.

Andritz Växjö uses the laboratory for customer projects as well as development projects. Thus, the laboratory is key in establishing firm legitimacy with customers. A Process Engineer at Andritz Växjö explained:
[The laboratory is for] the development of new test methods and for standard testing. It is about gaining support. It is a conservative industry, so it is important that the ideas are well founded. You can never present wild ideas. Nobody will buy them. You have to work carefully as you develop new methods. Everything must be documented carefully.

Fläkt Woods Växjö also uses the technical resources of offices, warehouses, a laboratory, and workshops. The firm has both development and customer projects although it prioritises customer projects. Nevertheless, Fläkt Woods Växjö uses its laboratory (i.e., the fan hall) to support technical activities in both customer projects and development projects. A Process Engineer at Fläkt Woods Växjö explained:

Fortunately, we still have our laboratory [from FI]. Although we have developed the ability to calculate performance theoretically, we still need one [laboratory] for verification and testing [of fans] for customers. Some customers require us to test the fans we deliver. We have a very good fan laboratory for that. I think it is one of the world’s leading fan laboratories. Our customers give us a lot of credit when they see what we do and can do.

All three firms support other organisation areas with their technical resources. For example, although Alstom Power Växjö focuses on development projects, they also support Sales. The Local Manager at Alstom Power Växjö explained:

When we have a project with a certain technology for a facility, we may need to look at things in the engineering phase. We may use a flow model to make sure there are no unnecessary risks in the layout design. Then we make a model, either by experimenting in the laboratory or by making computer simulations. We may be involved in making measurements. We are good at making measurements. […] Many of those who work with customer projects never notice the R&D department, but when we work together in projects, we become more visible. We show what we do and can do. We create customer value when we use our expert knowledge in these projects. Otherwise, customers might go elsewhere for projects.

The Technology Manager at Andritz Växjö described the use of the laboratory in customer projects:
We use it for customer projects and for testing materials. [...] for new kinds of materials. We conduct dry tests [for customer projects]. We also make improvements – heavier and larger changes. We test components. For example, we do a lot of tests on fans. We make tests with steam batteries. We collect samples when we build a number of smaller parts and measurement devices.

Fläkt Woods Växjö has close collaborations with other firms. Fläkt Woods Växjö not only uses its laboratory to support its projects but also for technical activities in support of other firms’ projects. Fläkt Woods Växjö also permits related firms to use its laboratory. The R&D Manager explained this collaboration:

We conduct a lot of tests for other Fläkt Woods firms. Because we have a great laboratory and three chambers for our fan wall, we conduct some tests for Jönköping, among others. We have also run tests for Colchester in England.

Information resources are a key factor in firm survival and growth (see Bharadwaj, 2000). The map of the three firms’ resources reveals they use various information technology resources in their operations. They use databases for information on products, processes, and tests. They also use technology resources for reporting systems although less so than for technical work.

The three firms use various engineering software programmes for design, calculations, and fluid simulation activities. These programmes are essential technical resources in the development and customer projects. In general, the three firms use similar software programmes.

Alstom Power Växjö uses information technology such as design software, calculation software, and simulation software. The firm also has an innovation system used to coordinate the work and to collect ideas for future development projects.

The R&D engineers at Alstom Power Växjö use the software programme CFD for simulations in development projects. CFD uses numbers and algorithms to analyse and calculate fluid flows (e.g., gas, water, and air flows). CFD produces a colourful map of the fluid flows: red indicates a fast flow; blue indicates a slow flow. Calculations for the analysis of fluids in channels or in other components are typically made in the various projects. A Process Engineer at Alstom Power Växjö explained:
CFD is for optimising and suggesting how a product can be improved [...] We may have a duct system, or maybe a heat exchanger, that we want in a certain way. There are a lot of questions. What if the pressure drops across this channel? There are a lot of technical flow issues.

These fluid flow analyses are critically important because product and process characteristics depend on fluid dynamics. The employees are very appreciative of the CFD tool. As explained in Chapter 4, depending on the nature of the actual project and its objectives, it may be sufficient to conduct only CFDs. A Program Manager at Alstom Power Växjö explained:

We have several projects in which we only make computer simulations. Then we trust CFD a lot. At that point, we have many correlations between reality and the computer algorithms that we trust.

An ambition at the firm is to use simulations as substitutes for advanced reality tests. However, the software must still be developed and validated before it can be used as a substitute for real life tests. A Process Engineer at Alstom Power Växjö described the situation:

The firm uses the programme [CFD]. We validate it, of course. This means when there are experimental data for a special case, perhaps a small cylinder or something, we validate the data using the programme. In real life, you may have channels that are much, much bigger. Then we need to validate the data from our perspective. There is also turbulence. Little swirls. You cannot solve fluid dynamics equations outright because they are non-linear. Different turbulence models were developed in the sixties to simulate turbulence in the best possible way. They were very rough and specialised, which meant that we needed to use the right model for the right purpose. There are many factors, so you must validate. It is important for us to know that what we see in the programme is reality. Otherwise, the design may be faulty.

A particular strength of the software is that it produces colourful maps that show the flows in customer projects. These maps can be shown to customers. A Process Engineer at Alstom Power Växjö stated:
CFDs look good. You get very nice, colourful pictures that can be shown to the customers. We say: “We have made a CFD, and you can you see how it looks”.

In essence, CFD can be used as a marketing tool with prospective customers as well as with established customers.

Both Andritz Växjö and Fläkt Woods Växjö use information technology to support their development and customer projects (e.g., design software, calculation software, and simulation software). A Design Engineer at Fläkt Woods Växjö commented:

In the past, one person made the drawings, and another person did the calculations. But that doesn’t happen anymore. Today, one person makes a three-dimensional CAD model of a fan. I then transfer the model to a calculation programme called ANSI.

The respondents emphasised the importance of these software programmes and how they facilitate and speed-up the development process. A Process Engineer at Fläkt Woods Växjö described his struggle to develop calculation software that will support the firm’s development activities:

I am a theoretician. Theoreticians like to calculate. I thought we could calculate how a fan performs. But we couldn’t. We [The R&D engineers] had a calculation programme that, to a limited extent, could make the calculations for the blade design that we then tested. We could not present theoretical performance diagrams for the fans. We needed to test. There were a lot of tests.

He also explained how they deal with the necessity of making theoretical performance diagrams.

We needed to make calculations for the fans. […] I developed a programme that could be used to calculate performance, but only for the rotors  […]]. In recent years I have brought in students to develop the programme. In 2003, a student came up with a theory. It was hard work because you have to do the calculations by hand. You cannot do these mathematical derivations with the software on your computer. You need pen and paper. It was a major job, but he did it very well. He also programmed the theory […].
He described the outcome of the work:

As the result of this work, we can make calculations for the entire process from inlet to outlet of the fan with a multi-stage rotor. The software will never really be finished, but we can still use it to make calculations for fans. Last week we had visitors from the US and France for training on the software. That was fun.

Fläkt Woods Växjö has put a lot of effort into developing software for making calculations of fan performance. The engineers are very positive about this software.

7.1.1.1 Determining the strategic relevance of the Technical Resources
The firms’ laboratory and workshops have the VRIN attributes. The firms require these resources for their operations given the products and processes they produce. Their development and customer projects have technical stages that require sophisticated engineering work – in other words, technical activities (e.g., drawings, calculations, and construction) that are supported by testing and validation. Management and the engineers regard testing and validation essential activities for making improvements, developing new ideas, and evaluating software calculations.

Frequently, development initiatives must be based on theoretical models. Each firm tests how its theoretical models and new ideas work in reality. Their advanced laboratories and workshops are key technical resources that support the new technological developments in their industry. As Black and Boal (1994) write, laboratories and workshops are valuable because they give R&D firms the capacity to innovate and thus achieve at expected and pre-determined performance levels.

The firms’ laboratories (owned and rented) are Rare. Alstom Power Växjö’s laboratory is unique in its industry. For example, Metzo Paper, a competitor, to Andritz Växjö, has similar test facilities (Löwstedt & Schriber, 2012, p. 39). However, a firm need not lose its rarity because a competitor has a similar resource and can copy activities.

Some resources are protected from imitation by property rights (e.g., by contracts, deeds of ownership, and patents; see Miller & Shamise, 1996). According to Das and Teng (2000), physical resources are well-protected by property rights. Alstom Power Växjö, which owns its laboratory, has such protection.
According to Andersén (2005, p. 32), it is difficult to substitute resources exactly. If the three firms’ competitors build or rent similar laboratories, they may be able to match the three firms’ R&D activities. However, an R&D laboratory is a major investment. For this reason, the other two firms in this study rent Alstom Power Växjö’s laboratory. From the perspective of Non-substitutability, this cost poses a significant financial barrier. Competitors can only overcome this barrier if they have sufficient resources.

The information technology resources are key tools used in various phases at the three firms. Satisfactory outcomes for both development projects and customer projects depend on these resources. As Powell and Dent-Micall (1997) conclude, information technology resources provide enormous productivity power if used appropriately.

The firms’ information technology resources are Valuable because they support the achievement of technical requirements and help meet customer demands. Many R&D activities would be impossible without these technical resources. Each of the three firms uses technology resources extensively – for customer requirements and for technological developments.

Information technology resources also help the three firms make cost reductions and reduce cost uncertainties in their projects. According to the informants, as the software improves, more accurate models can be made. The firms’ use of information technology has been useful in dealing with such cost issues. Not so long ago, engineers drew designs and made calculations manually. Today the assumption is that it is impossible to approach customers unless a firm can show it uses information technology for these tasks.

In short, the information technology resources provide Value because they support projects, increase efficiency, and reduce cost. These are the same conclusions that, for example, Powell and Dent-Micarell (1997) draw.

However, none of information technology resources of the three firms is Rare or Inimitable. Thus, they are not strategic resources. This finding confirms Powell and Dent-Micarell’s (1997) statement that information technology does not *per se* provide firms with competitive advantage. According to Barney (1991), a resource is rare when competitors do not have the same resource. The firms’ software programmes are commonly used by other firms in, for example, design and process activities. Other individuals, institutions, and firms can easily purchase the same software.
Because their competitors can acquire this same software, the firms’ information technology resources are not imperfectly Imitable. They are easily copied (see Barney, 1991; Porter, 2001). These firms cannot expect to achieve competitive advantage with such resources alone.

7.1.2 Financial Resources

Previous studies conclude that financial resources are essential for the support of a firm’s R&D activities (e.g., Cooper, 1999; Cooper & Kleinschmidt, 1995, 2007; Vieites & Calvo, 2011). At the three firms, financial resources, as a percentage of firm turnover, are set aside.

7.1.2.1 Determining the strategic relevance of Financial Resources

The informants recognize that the unavailability of financial resources constrains their activities. They must consider financial resources when they make project proposals. They have to estimate the initial and continuing costs of the projects.

According to Teece and Pisano (1994) and Helfat (1997), the lack of financial resources may limit a firm's R&D activities. For example, a financially strong firm is clearly in a better position than a firm with weaker financial resources. Adequate financial resources provide Value. Such firms have more flexibility in the conduct of their R&D activities. Most managers at the three firms want more financial resources to use in R&D.

The financial resources of the three firms are neither Rare nor Inimitable Given that their resources are a percentage of annual turnover, other firms can make the same, or better, arrangement, and thereby support their R&D.

The firms’ financial resources are not Non-substitutable. For instance, competitors that improve their publicly available credit rating may gain greater access to external sources of funds in the capital markets (see Del Canto & González, 1999). However, despite the advantages of leverage, too much firm debt can means more financial risk.

7.1.3 Human Resources

Knowledge, in its various forms, is essential for firms’ R&D activities (e.g., Fredericks, 2005; Kandemir et al., 2006). Knowledgeable people conduct R&D activities (Leonard-Barton, 1995). The informants from the three firms are highly educated and very experienced.
The human resources at the firms are the managers, Project Leaders, and team members, in addition to support staff. Many of these people work in project teams. Management establishes the teams with their leaders and members. These managers have various financial, marketing, and technical responsibilities and tasks.

From an organisational point of view, the firms are project-based. Project Leaders and project teams are significant resources in their product development (see Brown & Eisenhardt, 1995).

At Alstom Power Växjö, two Project Leaders are assigned to each development project – one with a traditional Project Leader role; the other with a technical role. The former deals with administrative issues, and the other deals with technical activities. Andritz Växjö and Fläkt Woods Växjö have only one Project Leader for each project. This individual is often the idea originator.

The three firms’ Project Leaders are important resources (see Brown & Eisenhardt, 1995; Clark & Fujimoto, 1991; Thieme et al., 2003). They improve communications between upper management and the teams. At Alstom Power Växjö, the technical Project Leaders understand the technical aspects of the projects and communicate this information to management and the team members. The same is true for the financial information that the traditional Project Leader communicates.

Cross-functional teams are another important human resource at the three firms. Such teams bring many kinds of expertise to projects and thereby contribute to the success of the projects. In short, cross-functional teams are useful in R&D firms because they increase knowledge sharing among team members (e.g., Song & Montoya-Weiss, 1998; Fredericks, 2005). The informants at the three firms praise the cross-functional team concept because it supports improved communications and exchange of expertise and experience.

Knowledge, which lies within people, (see Teece et al., 1997; Verona, 1999) may take different forms. The employees at the firms have knowledge: marketing, financial, and technical. Thus, they contribute to creating customer value and improving product performance.

The engineers at the three firms have the scientific, technical knowledge needed for the development projects and for the customer projects. With their different areas of expertise, the engineers bring different knowledge to the projects. For
example, at Alstom Power Växjö, knowledgeable personnel are particularly important in the development projects. The firm needs many kinds of engineers (e.g., mechanical, chemical, process, and electrical). The firm employs several of engineers with doctoral degrees who have deep specialisation in their scientific areas. The Local Manager at Alstom Power Växjö stated:

First, we have a pretty good mix of experience. We have relatively young engineers who come from the universities, equipped with the modern tools. We also have many R&D engineers with deep experience in our applications. Together, this group is very productive. The engineers are committed and highly educated and can work with the people who know our applications and the reality. We have 37 employees at R&D Execution in ECS [the division]. We also have 16 employees who work in another technical area called Carbon Capture. We also have 10 or 11 engineers with doctoral degrees in relevant technical areas, and about 20 with master’s degrees in engineering. The majority of the engineers have a chemical, machinery, or energy background.

Such people are also critical resources at Andritz Växjö and Fläkt Woods Växjö. At Andritz Växjö, knowledge of mechanical processes and automation is especially important. The Technology Manager at Andritz Växjö clarified:

We look at all different variants [of knowledge]. We have three areas. The automation engineers work with the electrical and automation elements. The design engineers and the process engineers, who have different backgrounds, work with the mechanical elements. Most of them have a Master’s degree. They may also work with chemical processes or technology processes. Many are mechanical engineers.

The Technology Manager at Andritz Växjö continued:

The traditional areas have mostly disappeared. The reason may be that firms have chosen the process direction. A Master of Engineering Education is much more like a degree in vocational education in which you learn where to go. The technology moves forward rapidly, so it is much like a toolbox. What do I do? This is the important question raised in a Master’s degree programme in Engineering Education.
As the informants stated, the engineers, who understand the air handling technology, are essential resources at the three firms. A Process Engineer at Fläkt Woods Växjö stated:

They [Alstom Power] work a lot with flow and aerodynamics in their products. It is actually air that links us.

A manager at Alstom Power Växjö stated that the engineers’ knowledge is an essential resource for their R&D work. Recruitment of competent and knowledgeable engineers is crucially important for the firm’s future. R&D managers at the other two firms agreed.

However, Andritz Växjö and Fläkt Woods Växjö still use outside consultants as complementary human resources. For example, an R&D engineer at Fläkt Woods Växjö said the firm deals with a consulting firm that supplies engineers who can make calculations and do design work.

In addition, Andritz Växjö and Fläkt Woods Växjö share their mechanical and process engineers on customer projects. Sharing resources is a way to increase knowledge among projects and project teams.

Additionally, although the informants did not make this point, the archival data revealed that managerial and marketing knowledge are also important resources at the firms. Each firm employs people with such knowledge. For example, several managers study the market, looking for new developments and innovations, identify customers’ demands, and make market analyses. They share this knowledge with other managers and the teams. Such knowledge is useful for formulating ideas for new projects.

7.1.3.1 Determining the strategic relevance of Human Resources
Knowledge is an intangible resource. It is often a catchall term for human skills, competences, experience, and know-how (Grant, 1991; Hall 1992; Bharadwaj, 2000; Wilk & Fensterseifer, 2003). According to Das and Teng (2000), knowledge refers to various forms of technical, creative, and collaborative skills.

The resource map revealed that the three firms have various human resources with different knowledge useful for business operations. Mechanical, process, chemical, and automation engineering are the ‘core’ scientific knowledge at the firms. Scientific technical knowledge is highly valued and sought after. The peo-
ple with this knowledge are extremely important employees. Without these human resources and their knowledge base – in effective combination – the firms would have difficulty in planning, executing, and completing projects that produce products and processes. In short, the firms would be unable to create customer value (see Barney, 1991).

The product and process areas at the three firms have their roots in FI and in air handling technology. Several of their products and processes are improvements on FI’s products and processes. To some extent, the three firms are rivals in some ways, especially in the competition for personnel who have the same knowledge.

Although there is a university near the three firms, most of their engineers were educated at other universities in the country. The firms compete vigorously for engineering graduates from these universities. It appears that human resources with scientific and engineering knowledge are Rare.

However, the firms also employ people of foreign nationality who have been educated outside the country. The recent trends in globalisation have created a global labour market that is very advantageous for the three firms. The firms hire engineers from abroad when they are unable to find enough Swedish engineers. Hitt et al. (2001) states that students from top universities receive the highest level of explicit knowledge, and have the high potential to learn and accumulate tacit knowledge.

Considering the supply of foreign-educated students, and the homogeneity of scientific/engineering studies, it can be argued that engineers are not Rare, Inimitable, or Non-substitutable. Such people are available. Therefore, scientific, technical knowledge is not a strategic resource. The same is true for managerial and marketing knowledge.

The interviews revealed that managerial and marketing knowledge are necessary in the development process, especially for decisions about teams, resource constraints, and project directions intended to ensure customer value and market acceptance. As other studies have shown, the use of teams for R&D activities is typical (Brown & Eisenhardt, 1995; Nambisan & Wilemon 2000). The cross-functional teams work toward common project goals that market demands inspire. If conflicts arise among project team members, the firms’ managers resolve these differences in coordination with Project Leaders. Thus, managerial and marketing knowledge is a Valuable resource that the firms for the R&D activities.
One possible problem is that the three firms’ rivals may have human resources with the same managerial and marketing education and experience. These people are also aware of market trends and how to sell their products and processes to customers. The explanation is the supply of human resources is homogenous.

However, as Hitt et al. (2001) point out, education and training provide high levels of knowledge in specialty fields. As a result, people do differ as far as their skills, competence, experience, and know-how. Some of these qualities are obtained not only by education and training but also by work with more experienced people. Similarly, experienced people can update their knowledge and skills by working with recent graduates. This cross-education is apparent at the three firms.

Knowledge that is firm-specific may sometimes be viewed as something “old” and as the “traditional way of doing things”. This attitude may pose hindrances to new and creative ways of thinking. However, the three firms have avoided this problem. They encourage newly graduated engineers to work closely with the more experienced engineers. This way of working fosters innovation and leads to the development of up-to-date products and processes.

Only a few individuals (e.g., R&D Managers and Product Managers) at the three firms make decisions, organise the work, survey the markets, and make market analyses. These people have a very deep and comprehensive understanding of the firms and of their markets. They are quite proactive in making managerial and marketing decisions. It is difficult for competitors to acquire the same resources.

This discussion leads to the conclusion that human resources are, in reality, quite heterogeneous. For this reason, competitors cannot copy these resources exactly or use comparable substitutes.

Firm-specific culture may be composed of shared values, assumptions, expected behaviour, and traditions. Firm-specific culture is reinforced and reshaped by everyday practices by firms’ human resources. At the three firms, this culture of an attitude toward the organisation and work derives from the engineering culture developed at Fl. This attitude is commonly referred to as the Fläkt Spirit (in Swedish, Fläkt Andan).
As Das and Teng (2000) state, it is difficult to imitate human resources or to find substitutes for them because of knowledge and information barriers. They observe that one problem with knowledge-based resources is their vagueness and ambiguity. Therefore, competitors are challenged to identify firm-specific knowledge among employees. Even when competitors can make the identification, they still have difficulty finding substitutes. On its homepage, Alstom Power Växjö, for example, states that the former SF influenced much of its firm-specific knowledge and technical know-how. The three firms share this same history. Other firms, lacking this history, cannot easily imitate or substitute their firm-specific knowledge.

One complication, however, is that competitors can hire a firm’s best human resources. Yet, as Das and Teng (2000) show, human resources often are imperfectly immobile. Contracts, including employment contracts, regulate many business and economic relationships (Hall, 1992). When employees leave R&D firms it is quite reasonable to expect that the firms will enforce any restrictive agreement terms and conditions.

Moreover, Das and Teng (2000) note that it is always possible that competitors will hire a firm’s employees. Yet a competitor is most unlikely to hire the entire staff. This can only be accomplished when one firm acquires another firm or part of another firm. Even then, there is no guarantee that the former employees will transfer to the new firm. The conclusion is that the personnel at the three firms are far from perfectly mobile. Human resources are inefficiently traded except when they are bundled with other resources such as physical resources.

7.1.4 Relationship Resources
Previous studies on R&D stress the importance of interaction with external partners, such as supportive institutions, customers, and suppliers. Relationships influence R&D efforts positively because they provide firms with information, resources, markets, and technology. Relationships are key resources for R&D firms.

The three firms share resources, in particular a testing laboratory. Andritz Växjö and Fläkt Woods Växjö rent laboratory space from Alstom Power Växjö. This is a convenient arrangement because Andritz Växjö and Fläkt Woods Växjö are geographically close to the rented laboratory.
The laboratory rental arrangement is an example of a productive and mutually beneficial relationship resource (see, e.g., Lavie, 2006, on such shared relationships). Because of their financial positions, two firms rent rather than own laboratories. As a result, the three firms share a strategic resource. As Lavie and Gulati et al. (2000) claim, relationships can give firms competitive advantage.

It is of interest that FI originally owned this shared laboratory (and workshops). For this reason, the three firms were familiar with each other’s activities at the laboratory. The firms had used the laboratory (and the workshops) for several years. They understood how they could use the laboratory (and the workshops) in their operations. The use of the laboratory and its workshops can therefore be linked to both a strategic perspective (i.e., to obtain important resources) and to a historical perspective.

The resource map shows that the three firms recognize the importance of good customer relationships. Each firm’s goal is to delivery projects that satisfy the customers. In working to satisfy their customers, the firms use their customer relationships to drive the technology forward while, at the same time, to minimise the risk of failure in meeting customer requirements. Furthermore, the resource map shows that, in most cases, the firms use their supplier relationships to obtain knowledge and to avoid developing products that cannot be manufactured with the supplier’s equipment.

7.1.4.1 Determining the strategic relevance of Relationship Resources
According to Gulati et al. (2000), a firm’s relationships can create inimitable and imperfectly substitutable value. The three firms interact and collaborate in the shared laboratory arrangement. The laboratory provides them with a ‘natural’ meeting place where they share a resource. This is a firm-to-firm relationship that strengthens the three firms in a very competitive industry. It is a relationship that has Value. Together, the firms exchange knowledge, encourage employee interaction, and promote innovation.

This firm-to-firm relationship is also Rare because of its exclusivity that is rooted in their shared history and geographic proximity. The relationship is also Rare as well as imperfectly mobile since it spans industries with a common technology. Together, this implies that their relationships could be characterised as imperfectly mobile (see Peteraf, 1993). Competitors may create their own collaborative relationships (i.e., business clusters). However, if competitors do not work closely
with the same technology, are not geographically close, and do not have a common history, the possibilities for creating such relationships diminish. The conclusion is that the relationship among the three firms is non-substitutable.

A fundamental assumption in the literature is that competitive advantage in achieved by meeting the demands and expectations of customers (Lüthje & Herrstatt, 2004; Enkel et al., 2005). The three firms make a special practice of including their customers in the planning/ordering phase. They listen and respond to customers’ demands and suggestions. Often, these demands and suggestions are linked to current products or processes.

Furthermore, the three firms include the customers in the test and pilot phases. For example, Alstom Power Växjö responsibly alerts customers when tests are too expensive or are delayed. Even very expensive tests may still be run if they push forward certain technical developments in an environment that is as close to reality as possible (e.g., using smaller or larger pilots at customer sites). A Program Manager at Alstom Power Växjö explained:

> Usually, you begin in the lab. Sometimes you begin on a very small scale – like a bench-scale. Later you build a model in the lab and conduct tests. In the next step, perhaps you make a little larger pilot to install in a real system and “borrow” a little gas to use in the pilot.

To deal with such situations, the three firms can use their customers’ test facilities because of their good customer relationships. These collaborations are important because they allow the three firms to tests pilots that they could not test in their own facilities. This arrangement is especially beneficial because many products are adapted to customers who may have specific environmental requirements. This is a common practice in B2B markets. There is no question that the three firms benefit significantly from the customer collaboration that advances their knowledge and technology.

The Technical Manager at Alstom Power Växjö commented on the involvement of customers in the development process:

> In the development activities, we involve the customers. After we evaluate new components, it is very common to make a test installation at the customer site.
A Process Engineer at Fläkt Woods Växjö elaborated on the situation:

You reach the point of, “If we do this with the fan, the customer will pay a higher price”. Then you have a competitive product. When we have reached that point, it's usually not as hard to implement it as it was to reach that point.

We need to listen to the customers and give them sales support. When Sales receives customer requests it does not know how to manage, the easiest thing is to make direct contact with Sales and learn what the situation is.

The resource map shows that the three firms also collaborate with their suppliers. For example, the firms are wary of producing products that have very challenging production issues and very high manufacturing costs. They work with their suppliers early in the development process to see if these problems can be resolved.

The Local Manager at Alstom Power Växjö described the supplier relationships:

We determine if there are providers who can deliver the important components […]. [We may ] not work as closely as we would like, but in development projects with important parts we try to involve the potential suppliers.

He continued:

At the same time, you can say that most of our products are relatively simple from a manufacturing point of view. Our area of expertise has more to do with what happens inside the reactors, such as in chemical reactions, streaming technology, or design robustness. The technical manufacturing issues are usually not too challenging. Our knowledge pertains to the process aspects.

A Mechanical Engineer at Andritz Växjö described the supplier relationships:

Typically, we make design changes if we find a good manufacturer or a cheap manufacturer. Hopefully both. We make some modifications during the discussions. Then the manufacturer
may say: “This is hard. Can we do it this way instead?” We respond: “If you do it like that, it will be fine”.

Then we send them the changes so they have updated drawings. There is an interaction, partly to reduce manufacturing costs and partly to adapt the manufacturing design.

A Process Engineer at Fläkt Woods Växjö described the supplier relationships:

When we begin to feel satisfied [with our ideas], we then have to evaluate those ideas. We have to find out if the cost is too high. If so, we have to see if another route is possible. Then we ask Purchasing to contact the supplier about the cost. We discuss the issue together.

According to the literature, collaboration with customers and suppliers (Cooper, 1999; Lüthje & Herstatt, 2004; Enkel et al., 2005) is essential at R&D firms (see also Ragatz et al., 1997). The three firms’ customer and supplier relationships are Valuable for both current and future projects. As explained, the firms’ relationships with their customers result in better products, satisfied customers, and cooperative supplier partners.

Competitors, of course, also try to establish good relationships with their customers and suppliers. Clearly, such relationships and networks positively influence a firm’s innovation capacity. According to Gulati et al. (2000), a firm’s network is usually idiosyncratic and more inimitable than its structure. They write: “For example, the existing choices of partner firms – either as buyers, suppliers or alliance partners can both restrict and enlarge the opportunity set of future relationships available for the focal firm” (Gulati, 1995, p. 208).

The air handling market is not as large as many consumer markets. Because their customers are limited in number, the three firms are able to develop exclusive relationships with some major customers. This exclusivity is a protection against competitors.

Moreover, because the three firms’ products are non-standard and are often sold with a service package, customer relationships may become long-term relationships. This, too, poses a barrier to competitors. Although their competitors may be aware of the link between the firms and their competitive advantage (i.e., there
is no causal ambiguity; see Barney, 1991), they may have difficulty in imitating products and thus use substitutes. However, substitution requires information that is unavailable to firms outside a network (Gulati et al., 2000).

Finally, the three firms’ relationship resources are idiosyncratic because they arose through unique collaborations. In short, the relationships are non-substitutable. Their customer-supplier-firm networks have the VRIN attributes.

7.1.5 Less Strategically Relevant Resources
Unlike industrial organisational economics, the RBV emphasises the internal aspects of the firm (Miller & Shamisie, 1996) and suggests that intelligent use of their strategic resources increases their competitiveness (Barney, 1991) and improves their performance.

Most of the three firms’ strategic resources (e.g., technical resources such as information technology) benefit their R&D activities. They provide their customers with up-to-date products and processes. However, this analysis of the mapped resources finds that some of the three firms’ resources lack the VRIN attributes that contribute to performance and competitiveness. The analysis also finds it is not enough that the firms own (or have the use of) their strategic resources. The firms also require complementary resources. That conclusion is counter to the RBV that maintains strategic resources are the main source of competitive advantage (see, e.g., Barney, 1991; Grant, 1991; Peteraf, 1993; Amit & Schoemaker, 1993).

The analysis of the three firms shows that complementary resources in combination with strategic resources can be fruitful. An example is when human resources with scientific knowledge use information technology. In some cases, this combination may even be required. For example, in the development process, testing requires various resource combinations, particularly combinations of strategic resources and complementary resources. While the analysis identifies the laboratory and human resources as strategic resources, it shows that human resources interact in the laboratory and use information technology to develop products and processes. Thus, one way to increase a firm’s competitive advantage is to search for ways to combine resources.

The analysis does not imply that a firm increases it competitive advantage by focusing only on the use of complementary resources, or combinations of strategic and complementary resources. Complementary resources, which are less strategically relevant, are additive resources.

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7.2 Summary of Research Findings of Strategic Resources in R&D Firms

The detailed mapping of resources shows that the three firms possess a number of resources that can be categorised under the following resource groups: technical resources, financial resources, human resources, and relationship resources. See Figure 17. The next section discusses these mapped resources.
<table>
<thead>
<tr>
<th>Resources</th>
<th>VRIN</th>
<th>Value</th>
<th>Rare</th>
<th>Imperfect Imitability</th>
<th>Non-substitutable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial Resources</td>
<td>Percentage of turnover</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Technical Resources</td>
<td>Modern open landscape offices (same building as the laboratory)</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Warehouses</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Testing facility</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Workshop (connected to test facility)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>3D CAD solutions</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Fluid flow, heat transfer, and fluid forces programmes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Human Resources</td>
<td>Technical Knowledge (e.g., Automation, Chemical, Mechanical and Process Engineering)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Marketing Knowledge</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Managerial Knowledge</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Firm-specific Knowledge</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Relationship Resources</td>
<td>Relationship with customers</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Relationship with suppliers</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Figure 17: Summary of mapped resources and their strategic relevance
7.2.1 Resources of Strategic Relevance or Complementary Resources

Based on the RBV, the analysis of the mapped resources shows that most of the three firms’ resources are Valuable. The firms use these resources to take advantages of opportunities in the market and to meet (or outperform) the competition (see Barney, 1991; Barney & Arikan, 2001, p. 142; Barney & Hesterly, 2008, p. 78). This conclusion supports Barney and Hesterly (2008, p. 78) who argue that many firms use their resources to exploit opportunities, neutralise threats, and increase revenues or decrease costs.

The Valuable resources are also strategic resources. These include test facilities, employees, and collaboration with external actors. The firms own or rent some of their technical resources. The value provided by a product or a process depends on, among other things, technical attributes and technical requirements. The air handling industry, in which the three firms operate, places high demands on technical performance (e.g., efficiency, quality, safety, and conformity with environmental regulations). Therefore, the firms require these resources to meet all these demands.

The firms’ laboratory and workshops support their testing activities in both development and customer projects. Such activities allow them to meet customers’ technical requirements, reduce technical uncertainty, advance development ideas, and evaluate software programmes. Of these resources, only the laboratory and the workshops are strategic resources in terms of the VRFIN framework.

Previous studies state that R&D firms should possess technical resources (e.g., Del Canto & González, 1999; Kandemir et al., 2006). This analysis takes the same position. However, this analysis contrasts with conclusions by RBV researchers who find that tangible resources (which are less likely to have the VRIN attributes) are less important to R&D firms than intangible resources. (e.g., Barney & Arikan, 2001, p. 139; Hitt et al., 2001; Čater & Čater, 2009). This conclusion among RBV researchers is of interest because, under generally accepted accounting principles, tangible resources (assets) appear on the balance sheet while intangible resources (assets) do not.

The analysis shows that the firms’ testing facilities are important technical resources because they support the development of new knowledge. They are the physical proof of the firms’ knowledge and testing capabilities. Thus, these tan-
gible resources are relevant in the implementation of strategy. The linkage between tangible resources and a firm’s competitiveness in the R&D setting is established.

A number of researchers have studied the role of human resources in business. The conclusion is that human resources are essential for successful R&D (e.g., Cooper & Kleinschmidt, 1986; Tushman & Nadler, 1986; Leonard-Barton, 1992; Fredericks, 2005; Song & Noh, 2006). However, some RBV researchers propose that intangible resources are essential for achieving competitive advantage (e.g., Barney & Arikan, 2001, p. 139; Hitt et al., 2001; Čater & Čater, 2009). The analysis of the three firms supports this idea.

The analysis shows that the three firms are very active in hiring people with the education and experience appropriate for air technology work and its administration. Many of these people are engineers with technical knowledge. Others have managerial and marketing education and experience. The firms develop this knowledge over time. As Löwstedt and Schriber (2012, p. 37) write, knowledge developed by Swedish firms is important to their survival.

However, it is challenging for the three firms to attract and employ technical people (i.e., engineers). There is a scarcity of such people. Despite this difficulty, the firms’ human resources have the four VRIN attributes. They are Valuable, Rare, Inimitable, and Non-substitutable.

The analysis shows that the three firms use their technical, managerial, and marketing knowledge to create value for customers. The managers, who understand the firms’ business strengths and the competitive environment, integrate this knowledge. Marketing managers hold information-sharing meetings and problem-solving meetings with the Project Leaders and project teams. The engineers use both technical knowledge and market knowledge in the development and customer projects.

Because the three firms’ technical, managerial, and marketing knowledge was developed over time through interactions with individuals within and outside the development processes, it is quite difficult for competitors to imitate this knowledge or to create substitutes for it. Human resources with knowledge are heterogeneous because of their complexity and differences.
Nevertheless, competitors may hire a firm’s human resources who are inimitable and non-substitutable although such people often have a high degree of imperfect immobility because of employment contracts (Hall, 1992; Das & Teng, 2000).

The analysis shows that the three firms have several relationship resources. These relationships are with customers and suppliers. Because of the nature of their markets, there are only a few buyers for the firms’ products and processes. Therefore, they must develop and maintain long-lived and exclusive relationships with customers (and with suppliers).

A truism in marketing is that customers like to deal with firms they have a good relationship with. This means firms should focus on customer needs (see Cooper, 1999). The three firms focus on developing such customer relationships, even to the point of including customers in the planning and development of products. Even suppliers are involved in these processes.

The firms have another important relationships resource: their relationships with other firms working in air handling. This includes the network of the three firms and the network of with other firms in the industry.

The three firms’ resources are idiosyncratic because they were created in a special, if not unique, collaboration that derives primarily from their joint history. Their competitors do not have this history, nor can they create it. The three firms’ collaboration is inimitable and non-substitutable. As Gulati et al. (2000) explain, their competitors, who lack the benefits such a special relationship confers, are unable to copy such benefits or find substitutes for them. This finding confirms previous research that emphasises that firms’ development settings support the relationships with customers and suppliers (Ragatz et al., 1997; Lüthje & Herstatt, 2004; Enkel et al., 2005).

In sum, the three firms’ technical resources (e.g., laboratory and workshops) have the four VRIN attributes (Valuable, Rare, Imperfect Imitability and Non-substitutable). The human resources with firm-specific knowledge and relationship resources also have these four attributes. As Figure 17 shows, only the testing facility, firm-specific knowledge and relationship resources, with the four VRIN attributes, are strategic resources. The other resources are complementary resources.
A final conclusion is that the RBV is useful in the discussion of the necessary conditions that allow an R&D firm to be competitive in a global industry. Alstom Power Växjö, Andritz Växjö, and Fläkt Woods Växjö meet these conditions because of their strategic resources. However, the analysis shows that, contrary to the RBV, complementary resources also provide competitive advantage. These resources also help a firm grow and survive in a competitive industry under the threat of globalisation.

7.3 Chapter Summary

This chapter analyses four resource groups of the three firms in terms of the VRIN framework. The analysis in this chapter elaborates on the RBV of firms (see Wernerfelt, 1984; Barney, 1991; Conner, 1991; Peteraf, 1993). The analysis describes which resources are strategically relevant for the three firms’ performance and competitive advantage.

The chapter finds some of the resources are strategic resources because they have all the four VRIN attributes. Other resources, the complementary resources, although lacking all the attributes, also contribute to the firms’ ability to perform in a very competitive industry. The complementary resources support the firms’ development and customer projects in important ways. Recent research after Barney’s (1991) article on strategic resources suggests that a sole focus on firms’ resources is limiting. By themselves, resources do not contribute a great deal. Therefore, it is important to study how resources are exploited. Penrose (1959/2009, p. 28) wrote that an administrative framework is used to manage the firm’s resources. Chapter 8 addresses management control of resources with specific reference to management control of R&D resources at the three firms of this study. In taking the management control perspective, the analysis deals with the last condition of Barney’s (1995) VRIN(O) framework.
Chapter 8: MANAGEMENT OF RESOURCES IN THREE CASES

This chapter analyses how the three firms manage their resources. The analysis follows Penrose’s (1959/2009) discussion of resource management. The analysis, which takes a management control perspective, is based on Simons’s LOC framework (see Chapter 2). The LOC framework has four concepts: Core Values, Risks to be avoided, Critical Performance Variables, and Strategic Uncertainties. These concepts are controlled by four systems: Belief Systems, Boundary Systems, Diagnostic Control Systems, and Interactive Systems. Thus the analysis deals with both financial and non-financial controls.

In the analysis, the chapter explores if the three firms fulfil the last condition of Barney’s(1995) VRIN (O) framework (see Chapter 2). In the analysis, the assumption is that the three firms have strategic (and complementary) resources that allow them to be competitive. The analysis is based in the empirical findings from the interviews and the archival data (see Chapter 6).

8.1 Management Control in R&D Firms

In addition to mapping the three firms’ resources, it is also possible to map how they organise their resources and direct their activities. Key management control elements can be identified and linked to various management control systems.

8.1.1 Organisational Structure

The choice of organisational structure influences how R&D strategy is implemented (e.g., Simons et al., 2000, p. 38; Malmi & Brown, 2008). A definition of an effective organisation structure is useful for understanding how firms achieve their objectives.

As Allen (2001) explains, R&D managers are creative when they develop new organisational forms. For example, both project organisation and matrix organi-
sation have roots in the management of R&D. In the matrix organisation, activities are structured around groups of people: by functions, products, or projects, or by both functions and products. According to Galbraith (1971, p. 29), “Each form of organizational design has its own set of advantages and disadvantages”.

Alstom Power Växjö defines its R&D as a separate function called R&D Execution. Thus, the firm’s R&D operations are a work unit in Sweden that is distinct from the Alstom Group’s other business operations. Alstom Power Växjö is, to some degree, an independent firm with multi-disciplinary human resource groups who work primarily with R&D and are accountable for R&D performance. Geographically, Alstom Power Växjö is also separate from the Alstom Group.

The main focus of Alstom Power Växjö is R&D for development projects. 7 IA described in Chapter 6, a parallel group (Technology) is responsible for strategy and finance related to the development projects. This parallel organisation consists of human resources called Program Managers. They are the links between Alstom Power Växjö and the Alstom Group. They manage the R&D activities not directly associated with the actual execution of development projects.

The Local Manager at Alstom Power Växjö described the organisational structure:

Previously, we received our assignments for product development from the business operations. We in R&D Execution worked without many exchanges with business operations and the cross-functions. We have a number of Project Leaders (Program Managers) for the development projects. Previously, our product leaders did a lot of technical work on the projects. Today they spend more time working with the cross-functional parts of the projects – communicating with marketing, managing the legal issues and patents, sourcing, and maybe purchasing. They spend more time making themselves visible in the business operations and the marketing operations. Because they have overall responsibility for the budget, their role now is that of project director, or whatever you would like to call it. They have more leadership responsibility. We in R&D Execution [the firm] place a greater focus on actually executing projects

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7 Alstom Power Växjö also has a support function. The firm provides expert help to customers as needed.
and managing the technical aspects of projects. […] Now there are two organisations that make the structure clearer.

Program Managers are responsible for the overall planning, control, and coordination of development projects, for ensuring the projects are completed within the time and budget parameters, and for verifying that the projects meet specifications. Program Managers are also responsible for the viability of development projects and for securing financial resources. This new position of Program Manager has created an additional management level that facilitates communication between the Alstom Power Växjö and the international division.

Alstom Power Växjö has a decentralised organisational structure that emphasises close interaction between the different functional groups and managers. As described by the informants, this organisational structure supports and facilitates the execution of R&D development projects. Alstom Power Växjö conducts its development projects ‘in-house’. This ‘in-house’ strategy means that management uses its own R&D resources.

Andritz Växjö has a specialised and decentralised organisational structure with human resources grouped according to functions. However, this firm does not have a purely R&D function. It does not have resources, engineers, or a laboratory specifically for R&D activities. The Technology Manager explained that Andritz Växjö has two responsibilities: development projects and customer projects.

At Andritz Växjö, the R&D activities are not isolated from the other divisions’ activities, such as Sales. In fact, R&D is closely integrated with other divisions, and customer and development project activities are conducted in parallel. The firm’s resources are divided among the various projects. The Technology Manager at Andritz Växjö described the complexity of this integration:

Competence is not easy. It is really hard. We have a lot of competence in-house. We have been through a generation exchange, which means that we have lost a lot. In an organisation like ours, we work a lot with customer orders. We have fantastic customer order processes. However, conflict between competence and competence depth may arise. This means we spend time in executing, calculating, and delivering a project; however, it doesn’t necessarily mean that we increase our competence. A conflict may easily result. In my opinion, as the person responsible for technology, I want to increase our competence so we can choose what is new. There are

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possibilities in the rather hard-edged technology like drying. Where does IT enter? Where does something else enter? How can we use the tools? When you focus on executing, as we do, this is a situation of potential conflict.

Fläkt Woods Växjö also has a specialised and decentralised functional organisation. Växjö, Fläkt Woods Växjö has two responsibilities: development projects and customer projects. The firm is small and lacks resources dedicated only to R&D execution. It also provides technical support for sales. The engineers focus primarily on providing this technical support to the sales group and on helping with customer projects. The R&D Manager described the effect of this organisational structure on the R&D activities:

We have not really had the resources in recent years for long-term, basic R&D. We also lack the ambition to conduct basic R&D that would result in revolutionary patents and newer stuff. We lack resources.

According to the informants at Fläkt Woods Växjö, the firm has decreased in size as a result of the specialisation and fluctuation in the economy. The Local Manager and the R&D Manager describe their complex struggle to balance the customer projects and development projects. With few permanent employees, management has to coordinate the resources among the projects very carefully. The R&D Manager commented on this struggle:

The development area is quite small. We have an aerodynamic engineer and a calculation engineer. We have our laboratory. We have one person who is responsible for tests of development projects in the laboratory. These people work mainly with R&D but with customer projects as well. The calculation engineer does all the calculations for customer projects. Depending on how many [customer] orders we have, he can spend up to 50% of his time in development. The aerodynamic engineer’s work is directly linked to R&D. Approximately 80% of his time is in R&D, and the other 20% is in sales support and customer projects.

One may ask whether sales support is more important than R&D. Are they equally important? If we have a customer project worth a hundred million [Swedish crowns], it is important to spend a lot of time on the order. I planned a development project, in R&D, that
was supposed to run the entire year. However, sales support was prioritized because of the hundred-million order. You fool yourself if you think you can conduct basic R&D with an aerodynamic engineer who works 80%, a calculation engineer who works 50%, and a lab, all within a budget of only two million. You cannot perform basic R&D then.

However, we still try to have a forum in which we think in new ways about how we can change our products, how we can improve our products, and if our products can be used in newer markets. We also have a new application – Carbone Capture – that captures carbon dioxide. This is an area in which Alstom conducts a lot of research. We recognize the need to conduct more long-term R&D so as to use our fans in that process.

The tendency in the firm is to prioritise the customer projects over the development projects. The technical functional group supports this work. Yet, according to the informants, they would like to be more engaged with development even though they do not have an R&D functional group or the necessary resources for tests and validations.

Managers at Andritz Växjö and Fläkt Woods Växjö, are very aware that they need to re-coordinate and re-prioritise available resources between the projects. It is an on-going problem. For example, it is typical for the firms to hire outside consultants when the workload is too much for the permanent employees. However, the managers are also aware that this flexible employment strategy may be necessary in economic downturns. The fixed costs of permanent employees can be reduced using the variable costs of temporary employees.

The Technology Manager at Andritz Växjö commented on the rental of resources:

It isn’t a huge amount of fixed costs. These are variable costs.

8.1.2 Belief Systems

Belief Systems inspire and empower people to generate new ideas and to look for new opportunities. According to Simons (1995, p. 34), everyone in a firm should understand the firm’s values, purpose, and direction. Senior managers should support belief systems through formal and systematic communication.
Belief Systems can be communicated on company home pages. Because these Internet home pages are global, they are an effective method of communication with firm personnel as well as with external actors (e.g., customers and others). For instance, on its home page the Alstom Group states it is “Shaping the future” (Alstom.com, n.d.). The Andritz Group states: “We accept the challenge” (Andritz.com, n.d.). Fläkt Woods states: “We bring better air to life” (Fläktwoods.com, n.d.-a).

Such statements about beliefs communicate the corporate goals and the corporate values. Senior managers at the three firms of this study use these expressions to inspire employees and set goals for the firms. “Shaping the future”, “We accept the challenge”, and “We bring better air to life” all express core values and performance expectations.

Belief Systems also inspire search and discovery among employees. For example, all three statements address the “future”. The Andritz Group and Fläkt Woods use the inclusive word “we” that supports the idea of teams and cooperation.

According to Simons (1995, p. 33), an organisation is created for a purpose. The Board of Directors’ Reports are one way the three firms communicate their purpose and direction. Alstom Power Sweden’s Board of Directors’ Report (Alstom Power Sweden Annual Report, 2008/2009, p. 2) states:

Alstom Power Sweden AB develops, sells and delivers equipment and services to power plants. The business covers steam turbines, generators, waterpower and equipment for air pollution control and complete plants. The business is in three main cities, Norrköping, Västerås and Växjö, and has nine local offices.

Andritz Växjö describes its purpose and direction more briefly. Its Board of Directors’ Report (Andritz AB Annual Report, 2008, p. 3) states: “Andritz plans, designs, and delivers plants for chemical and mechanical mass production for the pulp and paper industry”.

Fläkt Woods Växjö has a more detailed description (Fläkt Woods AB Annual Report, 2008/2009, p. 3):

Fläkt Woods AB develops, manufactures and promotes air climate solutions. The firm offers a full range of products for ventilation
and air climate systems with high standards of quality and function. The products are based on a holistic approach, which is based on unique experience and knowledge as well as adaptation to market requirements. The business operates in 20 cities in Sweden. During the year production has been carried out in Aneby, Enköping, Järna, and Jönköping.

In summary, these Reports communicate the purpose and direction of the three firms to interested parties. They are expressions of Belief Systems. Such Reports, by Swedish law, are public documents.

8.1.3 Boundary Systems

Boundary Systems establish limits and rules that must be respected within the organisation. While Belief Systems motivate human resources to generate new ideas and to look for new opportunities, Boundary Systems define the acceptable domains of the search. Planning, such as action control, is a type of Boundary System (Flamholtz et al., 1985; Merchant & Van der Stede, 2012, p. 306; Lövstål, 2008, p. 48). Plans allow managers to create limits and rules that must be respected (Simons, 1994, p. 170).

The map of the control elements for the three firms shows that they use plans for different purposes and in different contexts. First, they plan future R&D investments (i.e., strategic planning) in which R&D objectives are defined and projects are selected. These plans, which link to corporate strategy, take technological issues and market uncertainties into consideration. According to the informants, planning is essential because it provides a frame for comprehensive resource management.

Second, the three firms plan the execution of each development project (i.e. project management). This means planning (coordinating) the course of action that can achieve the objectives that were defined and outlined. There is a greater focus on the allocation of resources (technical and human) to the projects. The planning also involves customer involvement (e.g., for the installation of test pilots at customer sites) and supplier involvement (e.g., for avoidance of high manufacturing costs and difficult construction problems). Execution planning is thus more about proactively ensuring project performance through scheduling resources. This is resource management for monitoring resource allocation and use (Simons, 1994, p. 170).
Planning is problematic because it is difficult to foresee future events. Everyone
would like a crystal ball. However, the management control literature emphasises
that planning for the future is necessary, despite market and technological uncer-
tainties, especially in R&D. Management must develop guidelines to minimize
these uncertainties (Wheelwright & Clark, 1995; Song et al., 2007).

The Local Managers at the three firms have an important role in creating plans
and guidelines for future development projects. However, the corporate groups
control the extent and nature of Local Managers’ involvement. Although project
execution planning is primarily a firm-level activity, group-level upper manage-
ment has final authority.

For example, at Alstom Power Växjö development projects are chosen via inter-
action and communication between upper management and the firm’s parallel
organisation, marketing department, and the product managers. This means that
the engineers at Alstom Power Växjö have to influence decision-makers with
presentations of well-formulated project plans.

The informants stated they wish to improve and increase the communication
among the different parts of the division in ways that can foster diversity of input
and development of R&D ideas. For example, they said that Alstom Power Växjö
has several planning workshops annually where different areas in the division are
represented (e.g., marketing, sales, technology, and R&D Execution). They dis-
cuss business goals, marketing and technology strategies, and potential develop-
ment projects at these workshops.

Nevertheless, R&D planning at Alstom Power Växjö is really a top-down pro-
cess. The Program Managers have the central role in creating plans for future
R&D investments and in planning the actual execution of development projects.
They are described as the controlling Project Leaders who facilitate the commu-
nication between the managers and employees as well as who lobby for project
resources. The Technical Manager at Alstom Power Växjö stated:

Each Program Manager is responsible for projects in an area. They
plan the projects. Together, we estimate how many hours we think
it will take. [...]. If you want an R&D engineer to do a specific task
in a project, it is best to ask him or her about the number of required
hours. If the individual [the R&D engineer] is closely involved in
the estimations, the response will be as close to the truth as possi-
ble. [...]. Moreover, given the nature of development, you cannot
always know what you will discover. Our plans are constantly modified. Together we look at our resource pool and share tasks among the individuals we have. It is a living document that we review monthly. You take into account the changes that have occurred.

This comment indicates that planning at Alstom Power Växjö is characterised by openness and close communications. As the R&D Manager stated, development projects are difficult to plan because of their uncertain and explorative nature. Therefore, Program Managers and R&D engineers communicate frequently about plan modifications and resource allocations.

At Andritz Växjö, the group management also takes a role in the planning of R&D investments. However, such decisions are made in direct communication and close exchange with the Swedish firm. Managers at Andritz Växjö have responsibility for formulating strategy and planning objectives, which they present to group management for approval. This work is coordinated in several joint meetings in which various product and programme developments for the whole division are discussed. The Technology Manager at Andritz Växjö described the creation of plans and guidelines for future R&D investments:

[...] we set up a kind of framework for what we plan to do in the next year or next two years. [...] We then make a proposal for the products we are responsible for. Normally, we do this in August. In the next two months we have discussions with divisional management about acquiring products that match other products in the division [...]. We culminate with a final development plan for the upcoming year [...]. Then we have a comprehensive programme that is part of the whole [group]. In our programme, we define our goals. At that point, we have not dealt with specific project descriptions. The programme is at a more general level. At the end of the year, we begin with the project assignments.

Yet, despite the joint meetings and the discussions, clearly this is a top-down process of formal decision-making in the planning phases. However, Andritz Växjö managers have more influence in the planning for project execution. This planning is more informal. The firm’s engineers have responsibility for planning the project execution. The engineer who proposed the idea, or another engineer with available time, takes the position of Project Leader. In this role, the engineer has responsibility for estimates related to resources and costs. The engineer, as
Project Leader, also assembles the project team. A Process Engineer at Andritz Växjö stated:

To put together a project team, you ask around. Either you ask the managers if they have resources available, or you ask people directly, and then speak with the managers.

The project team, led by the Project Leader, works with other managers and other team members. The Technology Manager at Andritz Växjö explained:

It is usually a small project team with 3-4 persons. We then have a kick-off meeting where those of us in the project talk about what we want to do. [...] We distribute [tasks]. Someone will make the drawings, someone else will make the calculations. [...] There are different parts in a project.

At Fläkt Woods Växjö, upper management is closely involved in R&D investments plans. The Group’s Vice-President and the Local Manager have regular communications and interactions. For example, the Local Manager said that there are discussions on strategies and objectives for future R&D initiatives at regularly scheduled meetings. At those meetings, the Local Manager presents suggestions for development projects at the group level. The Local Manager explained:

At the beginning of each year or at the end of each year, we try to meet to discuss next year’s R&D. We have a meeting where we generally discuss what we think are potential development projects.

The same Local Manager emphasised the cooperative relationship:

Working with the R&D Managers and the R&D engineers, I need to build business cases to present to my managers. I need to say: “We need to do this in order to get this benefit”.

Business cases must be well developed and well presented. This requires the involvement of people from several different functions. Ultimately, in a formal,
top-down decision-making process, the decision to proceed with or halt a project is made at the group level.

However, the R&D Manager and the appointed Project Leaders at Fläkt Woods Växjö are in charge of the actual project planning. This planning is characterised by its informality and its good communications. The Project Leaders are responsible for the execution planning in collaboration with other Local Managers and engineers. The decentralised organisational structure facilitates the planning (See Section 6.1.4).

Budgets, which are a much-used instrument of control, are used at the three firms to establish and monitor compliance with limits and rules. Budgets are used almost universally in organisations (Bunce, Fraser, & Woodcock. 1995) and are one of the few control mechanisms capable of integrating the whole span of organisational activities into a single, coherent summary (Otely, 1999). Budgets may also be used, among other things, to implement plans, distribute responsibility, allocate resources, and provide transparency into a firm’s operations. Budgets can be defined as plans that have been translated into the financial terms of revenues and expenses. In other words, budgets are financial plans that describe the results firms want to achieve and how they plan to achieve these results.

The map of control elements shows that the three firms use budgets for these purposes. All the firms place a great deal of emphasis on their budgets because they define available resources (technical and human) in financial terms. The budget lets people know which development projects are approved and how many resources are allocated to them within specified time frames. This use of budgets is consistent with Simons’s (1994, p. 170) claim that budgets create an appropriate frame for resource usage. The three firms break their main budget into development project budgets that they can then use as guides to resource use. In this way, budgets remove the uncertainties about the limits of the resource use.

Financial planning requires good communications with transparent information sharing (Merchant & Van der Stede, 2012, p. 307). Such information, in smooth budgeting processes, is communicated among the different levels of the organisational hierarchy. Greve (2014, pp. 179-180) says budgeting can be a top-down or a bottom-up process. A top-down budget process means that senior management decides on the yearly financial goals and estimates the costs of higher-level tasks that influence the costs of lower level tasks. After these goals and estimates
are communicated to middle management, the main budget is divided into smaller budgets in which tasks are allocated funds.

The bottom-up budget process begins at the lowest level in an organisation where budget proposals are prepared for the various tasks and steps. These proposals identify the resources, including funding, needed to execute the tasks. Budget proposals from different parts of the organisations are then combined and used as base to develop the main budget.

The three firms of this study have adopted, more or less, the top-down budget format. There is some variation among the firms, depending on its corporate owners, as to the extent of the influence that each firm can exert.

Alstom Power Växjö has relatively little influence in the main budget discussions. The size of the firm’s budget is based on a certain percentage of the annual turnover. This is a fixed clause in the budget. The Program Managers at the parallel organisation are assigned parts of the main budget based on their R&D investments and their development projects. The Technical Manager stated:

Program Managers own the total R&D budget. [...] The manager of the Program Managers may compare a project that is running to a new suggested project, and then decide to move the R&D funds. [...] .

The Technical Manager explained, however, that the management at the firm can exert some influence on the size and allocations of the R&D budget (i.e., the resource limitations) by presenting well-prepared project proposals. As the informants explained, the R&D budget and the project budgets constitute a financial frame for the firm’s operations.

The Program Managers, who are responsible for the technology areas and their budgets, divide their allocated funds among minor project budgets. In this way, they link expected financial results to the development activities. The Technical Leads, who are in the firm’s organisation, assist the Program Managers with adapting the budget to the development activities. A Technical Lead described the collaboration with the Program Managers:

The idea is that they make a rough plan of when the gates will come in. We then make a bottom-up plan with the activities we want to do. You want them [the
activities] to match the budget, but it is not always possible. The budget may have to be adjusted. […] They [Program Managers] have the total budget that they divide into different portions. It means they have the top budget. They specify the amount first, and then what you want to do. When we [the Technical Leads] see what needs to be done and how many hours are needed for each phase, we then see how much money is needed at the end […]. We look at the resources, what needs to be done, and the costs. But it is difficult. When you do the first rough estimations, you cannot go into details.

Nevertheless, the budgeting process is a top-down process. Senior management prepares the main budget that is then sub-divided and communicated down the organisation by the Program Managers. The Program Managers and the Technical Manager explained that changes to the budget are outside the firm’s organisational boundaries. Of course, it is very challenging to match budget numbers to development activities with technical requirements.

According to the literature (e.g., Greve, 2014, p. 177), top-down budgeting is most used when management, that has an overview of all operations, wants to reduce expansion of the financial frame. Typically, a struggle results. The informants at Alstom Power Växjö described the difficulty of balancing financial limitations with execution of new R&D ideas.

Managers at the international division of the corporation approve the main budget for Andritz Växjö. This budget is a certain percentage of annual turnover. There are elements of the bottom-up budget process at the firm. The R&D Manager, who is very involved in the budgeting, is responsible for cost estimations and budget proposals. These data are presented to management at the group level. Together, management at Andritz Växjö and upper group management prepare the R&D budget. The Technology Manager explained:

[…] simply, there is a certain percentage of the results allocated to development. […] ‘How much R&D can we afford? […] Our norm is that we have to invest a certain amount in development, which is controlled by these issues: the number of people in the project; the cost; and the need to make these investments […]
There is a pre-determined framework, but you don’t get a project without having to justify why you should have it. That’s why we start working with next year’s development framework as early as the summer, several months in advance. When we come to the Autumn, when we are in the budget process, we know what we want to do. We have a strategic plan.

The advantage of the bottom-up budgeting process is the motivation and encouragement it gives to lower level managers/employees (especially the engineers who are the Project Leaders). When given the opportunity to present realistic cost estimations, they are part of the financial and strategic planning. This is true, not only for the development projects, but also for the customer projects. Given the way in which funds are allocated to R&D, management at Andritz Växjö has an interest in increasing sales of products and processes.

The Local Manager at Fläkt Woods Växjö explained that the corporation (group level) approves the R&D budget, which is based on a certain percentage of annual turnover. The Local Manager said he gives market and financial information and budget proposals to the Vice-President of the international division. The Vice-President uses these figures to prepare the main R&D budget. The Local Manager then sub-divides this budget into detailed financial plans. The Local Manager emphasised the importance of good budget proposals and plans:

We [the Local Manager and R&D Manager] decide together what we need to do from a technical perspective. At the presentation, our Vice-President says yes or no. If the answer is yes, we begin with a budget. We have previously made a rough budget so he has an idea about the costs of the proposed projects. Now we prepare a detailed budget and a resources plan that outlines the consequences for the rest of the business […]"

Because the Local manager and the R&D Manager at Fläkt Woods Växjö prepare budget proposals for corporate management, the budgeting process seems in some ways a bottom-up process. Both individuals are closely involved in the budget discussions. However, the bottom-up budget proposals are problematic because they are somewhat ambiguous with regard to the financial frame. Be-
cause the bottom-up process doesn’t directly mean budget increases, there is always a risk of frustration and decreased motivation when proposals are rejected, as they sometimes are.

Flåkt Woods Växjö is engaged with customer projects as well as development projects. Because its main R&D budget is based on a certain percentage of annual turnover, the firm focuses on customer projects. Indirectly, this focus influences the budget. The Local Manager explained this linkage:

The R&D budget for development follows the economic cycle sharply. When we have high turnover and good earnings, we have more development funds. However, normally, as a Centre of Excellence, we support our own R&D expenses. That is the core of the centre of excellence idea. Times are good when we make a lot of money. At other times, R&D suffers a lot […]. A complicated, high technology fan requires more development effort. It is not a cheap fan that anyone can make. This kind of concept changes sharply with the economic cycle […]. If you have lower turnover, it means in practice you lose your technical leadership to your competitors. A cheap fan is one that anyone can make.

By emphasising the linkage between the R&D budget and annual turnover, managers at both the group and the local level can motivate higher firm performance.

8.1.4 Diagnostic Control Systems

Diagnostic Control Systems help senior management to implement strategies designed to achieve specified goals (Simons, 1995, p. 59). Such control systems allow the organisation to achieve goals without managerial oversight. Therefore, managers should set appropriate goals, review performance updates and reports, and follow up on significant expectations (Simons, 1995, pp. 70-71).

The map of control elements shows that the three firms use performance reviews to determine if expected results have been or will be realised. These reviews are based on feedback loops that provide both procedural, financial, and productivity information from the various development projects. Managers at the three firms think diagnostic control systems are part of the management control that allows
monitoring of organisational outcomes and corrections of deviations (see Simons, 1994, p. 170).

Ferreira and Otley (1999) explain that performance follow-ups are an important activity. Such follow-ups should focus on areas senior managers consider important because success in those areas influences the growth and survival of firms. The development projects (progress and results) at the three firms are reviewed continually and compared to expectations (progress and results).

Performance evaluations at the three firms are made at regularly scheduled meetings during the entire R&D process. These evaluations examine and address variances from original project plans. The evaluations also consider whether examined projects are viable (i.e., the value produced compared to the resources spent). Even firm survival is a matter for discussion in these meetings.

As described in Section 8.13, the firms’ main budget specifies the kind and amount of resources to be used in R&D. Such resource allocations are the \textit{ex ante} quantities of financial resources that managers know they can use in overall R&D (Simons, 1995, p. 72). This resource frame, or resource limitation, is communicated in the main budget, which is then used to allocate resources to the development projects. The resulting project budgets propose the maximum financial resource spending in projects.

The project budgets are also used as the basis for diagnostic measurements. Such measurements (in formal, written reports) provide managers with financial and productivity information about the development projects. These reports are used to determine how to accomplish the projects’ objectives. At the three firms, a typical practice is to determine how resources have been used, if the resource use deviates from the budgets, the estimated costs of completion, the progress of the work, etc. Review meetings provide the opportunity to discuss the current resource availability for project completion and whether more funds should be applied for.

Alstom Power Växjö and Andritz Växjö conduct their development projects following a pre-defined R&D process. This means that both firms have a specified, sequential R&D process that involves multiple phases of development activities. These stages are well-defined in written documents that describe each phase in terms of expectations and achievements.
The development processes at Alstom Power Växjö and Andritz Växjö have several similarities with Cooper’s (1990, 2001, 2008) Stage-Gate model. For example, at Alstom Power Växjö firm group management has implemented review gates to evaluate project performance, which the firm in Sweden followed. The Local Manager stated:

We work accordingly to a structured R&D process. [...] This process consists of a number of gates. A compilation and documentation is made before every gate. There is an evaluation of the project at every gate.

At Alstom Power Växjö, the development projects are very much influenced by the formal development process. The review gates involve a number of specific criteria. If development projects fail to meet these criteria, they are halted (temporarily or permanently, as specified).

The development process at Alstom Power Växjö is designed to structure activities, secure required resources, and support market acceptance. Although the financial evaluation of the development projects is an important element in the evaluations, the analysis shows that market acceptance plays a major role in determining whether a development project proceeds to the next stage. Some informants expressed concerns about the prioritisation of market power over technology. A Manager at Alstom Power Växjö explained the design process:

We have many gates that control things in the different phases. At least, the market [department] will go through it all the time, looking at everything. I personally believe it can inhibit production. An I-phone could never have been made [...]. We would have tried to do it, but we would not have been able to do it because of how the market functions. We wouldn’t pass the first gate. [...].

The reason for this increased control, which began in 2002 or 2003, was the fact that Alstom almost went bankrupt but was saved by the French Government. This could not be allowed to happen again. I am absolutely convinced that this is not guaranteed by the processes we now have. You may encounter the same thing again.
By following and believing in the objectives of these processes, you have a clear structure. We know in principle how to develop things. The negative part is that it is nearly impossible to do something quickly. It is also very, very, very difficult to change direction radically when you have come a long way. If you have passed a certain gate, you have locked things up. It is not easy to change your mind. That is a problem for individuals.

The actual design of the development process reveals the desire of firm group management to decrease uncertainty (e.g., market, financial, and technological) that, in general, is linked to the firm’s R&D. Clearly, the firm group management wishes to use formal performance evaluations grounded in the idea of predictability, rationality and profit.

A similar evaluation procedure is used at Andritz Växjö. At Andritz Växjö, regularly scheduled meetings are held in which the performance of development projects is discussed. A Product Manager explained:

We go through [the project]. What is the status now? What are the results so far? Costs? We then try to determine if there are pictures, or anything, that describe what we have achieved. We get a little feedback […]. We take one project at a time. [We look at the] outcome and costs-to-date. We are tightly constrained by our budget. Should or will we exceed it? We have to make decisions […] to redistribute. We want results. It’s important. We emphasize that. What are our results now? You can work a lot and do nice things, but something must come out of it.

The progress of development projects at Fläkt Woods Växjö is also frequently reviewed. This firm also focuses on the viability of projects, necessary resources, and market acceptance. A Process Engineer at Fläkt Woods Växjö stated:

The development projects are continually evaluated. You see that this is not ideal. It is not what it is supposed to be. You have to take in new strengths, and re-do it. Otherwise, there is no point in continuing.
The evaluations at Fläkt Woods Växjö, which are less formal than at Alstom Power Växjö and Andritz Växjö, are less defined as far as written documentation about specific stages.

8.1.5 Interactive Control Systems

Interactive Control Systems are used to adapt to competitive environments by focusing attention and forcing dialogue. These control systems refer to formal information systems used by managers in their decisions about human resources such as subordinates. In practice, managers often refer to such systems as their “personal hot buttons” (Simons, 1995, pp. 95-96). A feature of Interactive Control Systems is the face-to-face meeting between, for example, managers and subordinates, where information is exchanged and discussed (Simons, 1995, p. 97).

Local managers and team members, with different knowledge backgrounds, at the three firms can meet, discuss, and analyse data about products and processes. These review meetings allow the three firms’ human resources to interact and communicate with each other. This setting encourages debate and analysis.

Simons (1995, p. 97) writes that Interactive Control Systems demand frequent and regular attention from managers at all organisational levels. The managers at the three firms pay such attention. At the review meetings, the firm group managers, for example, exhibit their interest in the three firms and their development projects. The firms’ managers suggest that the firm group managers, in this way, influence the progress of the development projects.

The Technical Manager at Alstom Power Växjö commented on the review meetings:

There is a review committee [representatives] from business and from technology, from slightly different parts in the corporation, who look at the development projects […]. The review follows the product development from concept to commercial implementation.

Firm group managers (marketing and operational managers) regularly review development projects at Alstom Power Växjö. Review teams of managers evaluate stage achievements and make decisions about continuing or halting the projects.
At Andritz Växjö the review process for development projects occurs mainly at the lower management levels. The progress of development projects is discussed at regularly scheduled meetings with the R&D Manager, the Product Managers, and the appointed Project Leaders. A Product Manager described attendance at such review meetings.

When we review, we call for an R&D meeting once a month. The Project Leaders, the product managers, and R&D manager are there.

With these ‘on-site’ meetings, there is less involvement of senior managers at the group level.

At Fläkt Woods Växjö the review meetings are less formal. The reviews are described as on-site reviews that are based on close interaction and communication with the Local Managers and the appointed Project Leaders. Other engineers sometimes attend these review meetings. A Process Engineer stated:

There are meetings, but you do not always take part.

Interactive Control Systems also promote information gathering and debate on assumptions and plans (Simons, 1995, p. 97). The analysis shows that the review meetings at Fläkt Woods Växjö, besides allowing various management levels and team members associated with the development projects the opportunity to meet and discuss, create an opportunity for developing new plans and modifying original plans. Citing Lawler and Rhode (1976, pp. 26-27) Simons (1995, p. 97), advances the idea that at “face-to-face meetings senior managers challenge subordinates to explain any unforeseen changes in their business or suggested actions plans and the assumptions that underlies their analyses”.

To maintain their influence, the managers at the three firms have to provide the firm group managers with information on a regular basis at the same time that they manage their subordinates and collect data about the development projects. The R&D Manager at Fläkt Woods Växjö explained that in addition to the on-site reviews, he has frequent communication with the firm group manager to update him about the development of projects. The R&D Manager described this work:

He [the firm’s group manager] comes here to conduct reviews. I report on our development projects. We
discuss different decisions based on the results so far. We decide whether to move to the next step. For ongoing development projects, we prepare a monthly report. The report presents some milestones, our achievements, and the amount earned. We review these at this meeting.

The informants also described their meetings with customers and suppliers where they learned customers’ needs and suppliers’ manufacturing capabilities. They described this exchange of information in positive terms because it allowed them, among other things, to develop their technological and marketing knowledge.

8.2 Summary of Research Findings of the Management Control in R&D Firms

In the next sections the findings from the analysis are explained. The analysis presents the role of management control in the development process. The analysis also shows, in the map of key control elements, how various control mechanisms are used in resource management at the three firms. The discussion is framed around the management control systems: Belief Systems, Boundary Systems, Diagnostic Control Systems, and Interactive Control Systems. The fifth attribute in Barney’s revised VRIN(O) framework (organisation) is added to the discussion. The guiding question behind the analysis is the following: “Is the firm organised to exploit the full competitive potential of its resources?” (See Chapter 4).

See Figure 18 for a summary of the resource management analysis.

8.2.1 The Role of Managers in the Development Process

The analysis of the RBV (see Chapter 7) suggests that people with managerial knowledge are essential for R&D firms. Such human resources are strategically relevant resources as defined in the VRIN framework. From the management control perspective, managers are essential in the development process. The managers at the three firms, who are very involved in the development process, focus on achieving the goals of their R&D projects. They promote and direct the innovation activities.
A business truism is that no firm has an endless supply of resources. Even if it did, adopting a simple ‘revenues-should-exceed-costs’ perspective means that firms’ managers (including R&D managers) should be thoughtful about how resources are organised and activities directed in the management of activities. The analysis of the three firms reveals that, although they operate in different types of development activities and approach these activities differently, they still need to manage their resources within similar financial and other resource limitations. For this purpose, the managers rely on both Boundary Systems and Diagnostic Control Systems.

The managers at the three firms also have to motivate and support creative thinking among their subordinates (i.e., individual employees and teams). According to the analysis, their managers use Belief Systems and Interactive Control Systems to promote such creativity and learning. As described by researchers such as Amabile et al. (1996), Burbiel (2009), and Lund (2012), creative thinking skills should always be encouraged, especially at R&D firms.

However, some studies have shown that management controls may discourage creativity (e.g., Amabile et al., 1996; Amabile, 1998). Therefore, it is the role of R&D managers to strike an effective and reasonable balance between creativity and control (Simons, 1995, p. 10; Simons et al., p. 4). Managers who can maintain this balance are well positioned to help R&D firms achieve success.

8.2.2 Management Control Systems used in Resource Management

As observed above, some studies argue that management control can be damaging in innovative environments (Amabile et al., 1996; Amabile, 1998; Andriopoulos, 2001). However, more recent studies on R&D and management control argue that such control may support the achievement of goals and performance expectations (e.g., Simons, 1994, 1995; Davila, 2000; Cardinal, 2001; Cedergren, 2011).

The analysis shows that the managers of the three firms use a combination of different control mechanisms to organise their resources and direct their activities. These control mechanism can be linked to different management control systems used to exercise both control and innovation. Figure 18 summarises the analysis of the control mechanisms.

In line with Simons (1995, p. 34), the analysis shows that the managers of the three firms use Belief Systems to communicate the values, purpose, and direction
of the firms to the human resources. Belief Systems can inspire and support people as they develop new and fruitful ideas at R&D firms. The analysis also shows how the managers use Belief Systems to communicate these same values, purpose, and direction to external actors.

The analysis shows that the managers use Boundary Systems for the allocation of resources. As Simons (1995, p. 39) proposes, such systems pin point the activity domains for human resources.

To specify these domains, planning is used an important control mechanism. The managers of the three firms use planning at various levels. On the strategic level, planning involves identifying potential R&D investments. On the group level, these plans are used in the allocation of resources. On the business level, planning involves the execution of projects.

Clearly, R&D spending (i.e., R&D resource spending) is a key issue for management (see Hartmann et al., 2006). Appointed Project Leaders also use planning to request and acquire certain resources for the development activities. On this level, planning involves scheduling the resource interactions so as to exploit the resources effectively. Some of this planning involves external actors such as customers and suppliers.

The managers at the three firms use Diagnostic Control Systems to ensure that the firms exploit their resources in pre-determined ways (i.e., by developing new, improved, and planned products and processes). Diagnostic Control Systems support the use of and the interaction between resources by ensuring that activities are completed properly. Performance evaluations and feedback mechanisms are used. At the three firms, resource usage is continually monitored.

The overarching domain at the three firms was is the financial resource frame (i.e., the main budget). This frame is sub-divided among minor financial resource frames (i.e., the project budgets) that are used in the execution of each project by comparing actual resource use to planned resource use. These comparisons are made in financial terms. The managers at the three firms emphasise staying within budgets. Thus, they carefully monitor project duration, market acceptance, project cost, and Project Leaders’ and project teams’ activities.

The analysis reveals differences in the level of managerial formality at the three firms. Two firms (Alstom Power Växjö and Andritz Växjö) use written documents that define the R&D processes. At Alstom Power Växjö, a review team of
firm group managers reviews the development projects. At Andritz Växjö, a Local Manager reviews the development projects on-site. At Fläkt Woods Växjö, less formally, a Local Manager and the appointed Project Leader review each development project. However, despite these differences, the purpose of all reviews is to determine that resources have been exploited as planned.

Interactive Control Systems are used to create communication and interaction among different human resource groups and to promote development of knowledge among the human resources. The informants said that the review meetings, which focus on performance evaluations, are directed towards maintaining the pre-determined domains such as the financial resource frames. However, they understand that these meetings are springboards for the resource management process of encouraging resource interactions and developing knowledge among the various human resource groups.

As Ferreira and Otley (2009) recommend, the three firms’ review meetings are essential managerial activities. The meetings give people the opportunity to interact in the exchange and discussion on the progress of the development projects. The review meetings also give the various management levels a forum in which people can share ideas and opinions as well as participate in decision-making activities (Simons, 1994, p. 171). In short, the meetings promote discussion of information, assumptions, and plans.

Meetings with customers and suppliers are also valuable. In such meetings, the firms’ managers can enter into technological and marketing dialogues.

In sum, while Belief Systems and Interactive Control Systems inspire and support creativity and learning in the human resources, the Boundary Systems and the Diagnostic Control Systems specify how these human resources should behave, set constraints on the use of resources, establish financial limits, and monitor employee behaviour in terms of performance. This promotion and monitoring of human behaviour is accomplished through the use of various management control systems (e.g., budgets and review meetings). This conclusion is consistent with perspective that claims management control involves ensuring that human resources must act in appropriate and desired ways if a firm is to achieve its objectives (e.g., Ouchi, 1977; Govindarajan & Gupta, 1985; Cardinal, 2001). The three firms emphasise developing intellectual resources (e.g., promoting knowledge development by interaction among employees) and protecting financial resources from misallocation (e.g., controlling excess expenditures).
The three firms’ relationships with external actors are only indirectly influenced by the management control systems. Their control systems focus primarily on resource management. That is the perspective of management control used in this study and in its integrated analytical framework (see Chapter 4).

8.2.3 The Influences from Senior Management

Foreign investors acquired the three firms of this study. The firms are now owned by multinational corporations with headquarters outside Sweden. If R&D seems a complex strategic activity, it is even more complex if one considers the fact such foreign-owned R&D firms are by definition situated in a different country than their owners. This study does not examine the relationship between the three (foreign) firms and their corporate owners. This study only examines the three firms. However, it is impossible to disregard the fact of foreign ownership and its influence on the three firms. In several instances, the influence of the multinational corporations is remarked on in this study.

The analysis shows that the three firms have decentralised organisational structures. This means that corporate management shifts some of the decision-making authority to the three firms’ managers. However, in no instance do the corporate owners surrender all such authority. Their influence is apparent in their proactive coordination of the R&D at the three firms – always with corporate interests at the forefront.
<table>
<thead>
<tr>
<th>Management Control Systems</th>
<th>Financial Resources</th>
<th>Technical Resources</th>
<th>Human Resources</th>
<th>Relationship Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belief Systems</td>
<td></td>
<td></td>
<td>Values, purpose and directions were formally communicated (e.g., through home pages and board of directors reports)</td>
<td>Values, purpose and directions were formally communicated (e.g., through home pages and board of directors reports)</td>
</tr>
<tr>
<td>Boundary Systems</td>
<td>Limits and Rules were established through financial planning (e.g., overall budget and project budgets)</td>
<td>Limits and Rules were established through formal planning (e.g., planning for execution of development projects.) Overall budget limited the available resources. Project execution planning ensured the accessibility of technical resources. It was also used to ensure that appropriate types of technical resources were available and sufficient. Formal planning (e.g., schedules &amp; coordination) was used to set rules for how technical resources should interact with other resources and to determine limits for technical resources exploitation within projects</td>
<td>Limits and Rules were established through formal planning (e.g., planning for future R&amp;D investments and execution of development projects.) Overall budget limited the available resources. Project execution planning ensured the accessibility of human resources. It was also used to ensure that human resources with the appropriate knowledge were available and sufficient. Formal planning (e.g., schedules &amp; coordination) was used to set rules for how human resources should interact with other resources and determine limits for human resources exploitation within projects.</td>
<td>Planning took place about involving customers (e.g., to carry out tests at customer sites) and suppliers (e.g., to plan for manufacturing) in the development process</td>
</tr>
<tr>
<td>Diagnostic Control Systems</td>
<td>Deviations from pre-set standards of performance were monitored and corrected through reviews and evaluations. Actual use of financial resources was reviewed continuously based on the pre-determined financial resource domains.</td>
<td>Original outcomes and deviations from pre-set standards of performance were monitored and corrected through reviews and evaluations. How technical resource had been exploited within the development projects and the out-put of the exploitation were reviewed continuously based on the pre-determined resource domains (e.g., financial domains).</td>
<td>Original outcomes and deviations from pre-set standards of performance were monitored and corrected through reviews and evaluations. How human resource had been exploited within the development projects and the out-put of the exploitation were reviewed continuously based on the pre-determined resource domains (e.g., financial domains).</td>
<td></td>
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<tr>
<td>---------------------------</td>
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<td>------------------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Interactive Control Systems</td>
<td>Attention was focused and dialogue was forced throughout the organisation by the support of face-to-face meetings, review meeting and involvement of different management levels. The different type meetings supported communication and interaction among different human resource groups and promoted development of knowledge among the human resources.</td>
<td>Dialogue with customer and suppliers to obtain information and develop marketing and technology knowledge</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 18: Summary resource management by management control systems
8.3 Chapter Summary

This chapter presents the analysis of the three firms’ resource management. The mapping and analysis of their key elements of control illustrate that the control mechanisms are visions, plans, budgets, and meetings. These control mechanisms are traced to their management control systems: Belief Systems, Boundary Systems, Diagnostic Control Systems, and Interactive Control Systems, according to the LOC framework.

The three firms use the control systems mainly to influence the behaviour and performance of their human resources. The firms use Belief Systems and Interactive Control Systems to inspire and encourage people’s creativity and learning. Boundary Systems and Diagnostic Control Systems are used to prescribe and monitor human resource behaviour, define constraints, and establish limits.

The analysis also reveals that management uses these systems primarily in its focus on internal rather than external resources. The firms’ access to resources is only indirectly influenced by the control systems. These findings are consistent with the general commentary on management control that maintains the purpose of management control is to manage human resources so that they act in ways that help firms achieve their objectives (e.g., Ouchi, 1977; Govindarajan & Gupta, 1985; Cardinal, 2001)
Chapter 9: INTEGRATED RESOURCE MANAGEMENT FOR R&D FIRMS

This chapter explains how an R&D firm can manage external and internal competition. An integrated view of resource management is used in the explanation.

The chapter is based in two assumptions – first, that R&D firms can perform at expected and pre-determined levels of performance in accordance with their strategy and objectives (Chapter 7); second, that R&D firms can be competitive because of how they manage their resources (Chapter 8). The Integrated Resource Management model presented in this chapter is based on the analyses in these two chapters.

The chapter begins with a brief discussion on the managerial complexities in an innovative R&D environment. Next the Integrated Resource Management model is presented. The next section discusses the history of SF/FI, which is the “mother firm” of the three firms of the study: Alstom Power Växjö, Andritz Växjö, and Fläkt Woods Växjö. The chapter concludes by explaining why these three firms use the alternatives presented in the Integrated Resource Management model.

9.1 Handling the Management Problem

As described in Chapter 3, the core management issue for R&D firms is the tension between innovation and control (Simons, 1995, p. 10; Simons et al., 2000, p. 4). Simons (1994, 1995) suggests that this tension is best managed with the use of Belief Systems, Boundary Systems, Diagnostic Control Systems, and Interactive Control Systems. These management control systems can be used to organise and direct activities in innovative environments.

As the two previous chapters explained, the three firms of this study use these management control systems. They use these systems to access and manage their
various resources. The conclusion is that the firms choose among the managerial alternatives in the Integrated Resource Management model.

9.1.1 An Integrated View of Resource Management

The analysis of resource use by the three firms reveals they focus on various resources (especially human resources) and their management. The firms’ aim is to manage these resources effectively and efficiently in their very competitive industry despite the limitations, constraints, and other problems related to these resources.

The three firms’ ability to be competitive derives from the resource management of their strategic (and complementary) resources. Despite some differences in how they manage these resources, the analyses in Chapters 7 and 8 reveal the firms use two principal strategies to access needed resources and to manage such resources.

The three firms access resources in three ways: ownership, rental, and hiring. See Figure 19.

<table>
<thead>
<tr>
<th>Firm</th>
<th>Resource Accessibility Strategy</th>
<th>Internal</th>
<th>External</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alstom Power Växjö</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Andritz Växjö</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Fläkt Woods Växjö</td>
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<td>✓</td>
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</table>

Figure 19: Resource Accessibility Strategy

To supplement owned resources, an R&D firm may acquire resources from external actors. There are various reasons for this resource strategy. For example, when permanent employees cannot manage excess workloads, an R&D firm may hire temporary employees (consultants) with specialised knowledge of electronic, mechanical, and process engineering. An R&D firm may also rent warehouses and test facilities with various floor areas, configurations, and equipment. The use of the hiring/rental resource strategy, which has both advantages and disadvantages, requires consideration of such factors as location, duration, and cost.
The use of outside consultants also requires consideration of the division of labour between the permanent employees and the consultants.

As Figure 19 shows, the three firms differ in their resource accessibility strategies. Alstom Power Växjö has an internal strategy (the informants describe it as the ‘in-house’ strategy), which means the firm owns its laboratory, workshops, and software (its technical resources) and, in the main, employs engineers (its human resources) on a permanent, full-time basis. Andritz Växjö and Fläkt Woods Växjö, however, have an external strategy. Both firms rent test facilities and hire temporary consultants to supplement permanent staff.

Although, in general, the firms’ resource accessibility strategies are primarily external or internal, of course, there is some overlap of strategies. For example, Andritz Växjö and Fläkt Woods Växjö sometimes use a more internal resource strategy. In economic downturns, when customer orders decrease, the two firms necessarily suspend the employment of outside consultants. In addition, in anticipation of such times, and wishing to avoid redundancies, the firms also maintain only a critical level of permanent staffing. Even Alstom Power Växjö at times hires consultants when there is extra pressure to complete projects.

In terms of management control, two firms use explicit management control and one firms uses implicit management control. See Figure 20.

<table>
<thead>
<tr>
<th>Firm</th>
<th>Management Control</th>
<th>Explicit</th>
<th>Implicit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alstom Power Växjö</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Andritz Växjö</td>
<td></td>
<td>✓</td>
<td></td>
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<tr>
<td>Fläkt Woods Växjö</td>
<td></td>
<td></td>
<td>✓</td>
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</tbody>
</table>

Figure 20: Management Control

The difference in the use of management control by the three firms derives from the extent of the influence by their corporate owners. The analysis of the map of control elements shows that the firms’ plans (i.e., strategic planning, project execution planning, and financial planning) guide their activities and are linked to
the choice, allocation, accessibility, and scheduling (i.e., the management) of resources. Upper management levels communicate these control elements (i.e., mechanisms) and standard procedures (Simons, 1995, pp. 40-41) that set limits and require compliance with rules and respect for particular values.

The analyses in the two previous chapters also show that the firms take two main approaches to ensure that their activities serve firm objectives. The first approach involves performance evaluations in which organisational results are evaluated so that differences from expected results can be addressed. The second approach involves the use of regularly scheduled meetings in which Project Leaders, Project Managers, and group-level managers have the opportunity to participate in overall firm decision-making.

Performance evaluation of the development projects requires making measurements and (sometimes) adaptations. Budgets and review meetings are used to control that resources are exploited according to plans. The three firms’ performance evaluations differ in their degree of formality.

For instance, Alstom Power Växjö and Andritz Växjö use formal development processes with control checkpoints (e.g., “Stage Gates”). These structured processes are documented. Fläkt Woods Växjö uses informal control measures, which are not documented and are less structured although the firm has review procedures.

The three firms’ overall managerial philosophies influence their choice of management control systems. Project Managers appoint the Project Leaders and assist in the selection of team members for the cross-functional teams that support the versatility and creativity needed in the development projects. Managers, who select and prioritise the projects, are also informally involved in the work of the projects. They interact with Project Leaders, other engineers, and various other personnel. In this way, the Project Managers supplement the formal budget communications.

The three firms encourage direct personal contact among firm-level and group-level managers. Communications among these people is frequent and open. One forum for such communications is the review meeting in which people (e.g., Project Managers, Project Leaders, and engineers) from various key areas discuss the development projects and make decisions about them. The literature supports this way of working because of the claim that informal communications may produce new ideas and new knowledge (e.g., Brown & Eisenhardt, 1995).
The three firms differ, however, in the formal decision-making on strategic planning and financial planning. At Alstom Power Växjö, a parallel organisation and the Program Managers make these decisions with little involvement of the firm’s lower-level managers. They communicate with group-level managers. Thus, the bureaucracy increases. At Andritz Växjö and Fläkt Woods Växjö, the firms’ managers are highly involved in the strategic and financial discussions.

Different management levels review performance at the three firms. At Alstom Power Växjö, group managers and Project Managers from the parallel organisation (Technology) review the development projects. At Andritz Växjö and Fläkt Woods Växjö, performance reviews are based on close interactions and communications with a few group representatives and with the firms’ managers and other employees.

Figure 21 is a graphic representation of management control at the three firms. In the figure, explicit management control is the result of clearly formulated and documented routines and procedures. Implicit management control is the result of less clearly formulated and documented routines and procedures.

<table>
<thead>
<tr>
<th>Explicit Management Control</th>
<th>Internal Resource Accessibility</th>
<th>External Resource Accessibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alstom Power Växjö</td>
<td></td>
<td>Andritz Växjö</td>
</tr>
<tr>
<td>Implicit Management Control</td>
<td></td>
<td>Fläkt Woods Växjö</td>
</tr>
</tbody>
</table>

Figure 21: The Integrated Resource Management at the three firms

While the three firms use fairly comparable control mechanisms, the analysis shows that they address the management problem (i.e., balancing innovative efforts and control) with integrated resource management. As Figure 21 shows, the firms use either explicit or implicit management control systems, and rely on either internal or external resource accessibility. Alstom Power Växjö uses explicit management control and relies on internal resources. Andritz Växjö uses explicit
management control systems and relies on external resources. Fläkt Woods Växjö uses implicit management control systems and relies external resources. None of the firms uses implicit and internal management control systems (the bottom-left quadrant is vacant). The chapter now turns to a discussion of FI, the “mother firm” of the three firms.

9.2 Understanding Integrated Resource Management as in Terms of Vintage Clothes

The SF (AB Svenska Fläktfabriken) story illustrates how a successful industrial firm can disappear, only to reappear in other forms. SF’s strategic decisions, investments, and operations influenced each of the three firms of this study. SF was a successful company in terms of growth and market leadership. Its R&D activities accounted for much of its success. SF’s subsidiary, FI (Fläkt Industri) conducted these R&D activities that involved the development of various products and processes. All three firms in this study spun off from FI, following the foreign corporation acquisitions.

The three firms have strategic resources and complementary resources that support the development activities they manage with various formal and informal control mechanisms. The resources and the control mechanisms are in large part legacies from FI. Sections 9.2.1-3 review the historic roots of Alstom Power Växjö, Andritz Växjö, and Fläkt Woods Växjö.

9.2.1 Vintage Acquisition and Development of Strategic and Complementary Resources

FI relied on the use of technological advances in each of its four business areas. It also used synergies among the areas to manage its resources.

Greener (2002, p. 614) describes firm histories as “[...] profoundly important”. This is true of the three firms of this study. Alstom Power Växjö (and the other two firms) benefited from FI’s decision to build a laboratory and workshops. R&D studies that take the RBV (e.g., Kandemir et al., 2006) discuss the benefits a technical resource, such as a laboratory, can bestow on a firm in the support of its technical resources and competences. FI’s R&D activities required a large laboratory and workshops for conducting experiments, tests, and validations of
new ideas and technological solutions. This laboratory and its workshops were major investments by SF and FI that supported its technical expertise.

Alstom Power Växjö acquired the laboratory and workshops that were owned by SF and FI. The other two firms of this study now rent space in the laboratory and workshops. The map of the firms’ resources shows that the technical resources (the laboratory and the workshops) have the strategic attributes of the VRIN framework. The firms use these resources for the same purposes that FI did. As (Greener, 2002) writes, history matters. Past activities can support future value-creating strategies (Barney, 1991, 1995).

In addition, the importance of the firms’ history is shown in the restructuring that followed the break-up of FI into the smaller firms. Because FI had R&D facilities, customers, suppliers and a good reputation, the three firms faced fewer entry barriers to a very competitive industry. The acquiring multinational corporations saw no advantage would be gained by relocating the three firms abroad. The three firms of this study remained in Sweden, in the same general area in which FI had operated.

A decision for the corporation that acquired Alstom Power Växjö was whether to move the laboratory and workshops. Would more be gained than lost if the laboratory and workshops (including very delicate equipment) were moved abroad? It is not cheap to move such resources. The corporation ultimately decided against the move, not only because of the direct moving costs but also because of concerns about the loss of markets and reputation in Sweden. History matters.

FI had dealt with many issues and problems related to experiments, tests and validations for development activities. Many of these issues and problems originated in legal requirements and industry standards. The three firms, naturally, face the same issues and problems. However, they benefit from the knowledge and experience that FI acquired in dealing with such matters because their products and processes are similar to those FI produced.

FI’s air handling technology was based in firm-specific knowledge developed under SF’s management. Although air technology was an unexplored research area when SF was founded, the company acquired its advanced knowledge by its support of technology and engineers and by its construction of a laboratory and workshops. In the early 1930s, SF’s management invested more money in technical development than in product development (Andersson, 2002).
As SF’s R&D subsidiary, FI in time gained the trust of the air handling industry and established its legitimacy as a significant actor. FI created a brand recognized for the quality of its relationships and its good work (Turnbull, Cunningham and Ford, 1996). FI used its laboratory and workshops as marketing tools. Customers who visited the laboratory saw impressive possibilities, not only of the laboratory itself but also of FI’s technically trained and experience employees. FI was recognized as an entrepreneurial and technology-driven firm.

The three firms have built on FI’s reputation. One informant emphasised that some customers buy their products specifically because of the Fläkt name. It is a very valuable business legacy. Even when a firm moves away from its historic roots as technologies change, it can benefit enormously from a brand name associated with high quality. If a brand is managed carefully, a firm may even survive an acquisition.

A firm’s interactions (relationships) with others are strategic resources (Gulati et al., 2000; Lavie, 2006). Informants at the three firms emphasised how important it is to hire engineers with skills in design and knowledge of electrical, mechanical, and automation processes. FI employed engineers with these skills and knowledge. After some start-up hiring difficulties, FI began to employ engineers from Swedish universities. An entrepreneurial engineering atmosphere and work culture developed over time at FI. The informants, who inherited this culture, call it Fläktandan (i.e., the Fläkt Spirit).

FI also had good relationships with various universities and institutions. FI supported scientific research and was a member of several research committees. FI’s management also promoted academic research, supported the doctoral studies of a number of its engineers, and cooperated in university programmes on business-related problems. In all these activities, FI gained as much as it contributed. FI made contacts that led to the employment of engineers and also increased its innovation capabilities.

FI also developed good relationships with customers. According to R&D research, such relationships contribute to firm success (e.g., Cooper Ragatz et al., 1997; Lüthje & Herstatt, 2004; Enkel et al., 2005). For example, FI engineers worked closely with customers to develop products and processes in mutually advantageous collaborations. As it solved customer problems, FI also developed its marketing and technical knowledge and skills. The three firms inherited these loyal customers.

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In sum, there was a “resource transfer” from FI to the three firms of this study. The resources included technical and human resources consisting of knowledge and skills, solid relationships, a good reputation, a brand name, tangible assets (the laboratory and workshops), and more. This “resource transfer” was possible because of the extensive firm documentation and the employees who followed the FI business areas to ABB and later to the three firms.

9.2.2 The Vintage Handling of the Management Problem

The analysis shows that FI exploited the resources it owned. Although FI developed strong relationships with customers, suppliers, and academics, its main focus was acquiring resources, particularly technical resources and human resources. FI had an internal resource accessibility strategy. See Figure 22.

<table>
<thead>
<tr>
<th>Firm</th>
<th>Resource Accessibility Strategy</th>
<th>Internal</th>
<th>External</th>
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<tr>
<td>Fläkt Industri (FI)</td>
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Figure 22: Resource Accessibility Strategy at FI

Alstom Power Växjö has followed in FI’s footsteps as far as adopting a resource accessibility strategy. FI used its human resources in interactions with institutions such as universities and with customers to develop its knowledge. These relationships supported the resources FI owned.

FI’s management control system was more implicit than explicit. See Figure 23.

<table>
<thead>
<tr>
<th>Firm</th>
<th>Management Control</th>
<th>Explicit</th>
<th>Implicit</th>
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<tr>
<td>Fläkt Industri (FI)</td>
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Figure 23: Management Control at FI
Fläkt Woods Växjö also uses an implicit form of management control that may remain as a legacy from FI. FI’s resource management took an explorative focus that was supported by its license system. According to the informants, FI’s license system was an important asset because it meant FI owned the technology in the group; the other business areas had licence agreements with FI that meant they had to pay a fee for the use of FI’s technology. Because FI owned the technology, it was also responsible for conducting the R&D activities that would support the various areas in the group. Representatives from these areas formed an R&D council that allocated the financial resources after approving development proposals.

Thus the license system was a mechanism upper management used to control the R&D activities. The system was a way to manage resources through the allocation of financial resources. The system also supported exploration by its focus on communications and by its encouragement of the entrepreneurial engineering culture. The informants said that the license system provided financial stability and the freedom to explore and experiment because several business areas (i.e., the other subsidiaries) contributed the financial resources. If there were a decline in turnover, then the other areas would provide support.

In various ways, implicit management control at FI was evident. One example is how the development projects were initiated and how the project executions were planned. For example, FI did not define its development processes or divide them into different stages. FI developed relationships with customers and tried to maintain connections with its markets. This way of working meant that many of its development projects originated in ideas from R&D engineers who had worked closely with customers and their projects. Sales representatives, worldwide, also offered many development project suggestions.

A former R&D Manager explained that he had implemented an idea search at FI. He explained that FI employees could present and discuss R&D ideas at any time with the R&D Manager. This manager collected ideas and presented them to the R&D council. Employees could offer ideas even informally, such as at coffee breaks. According to this manager, R&D and Sales worked closely at FI. They ‘sat’ (physically) near each other. Thus the R&D department were well aware of customers’ needs and requests.

Another example of FI’s implicit management control is evident in how the Project Leaders were selected and the project teams were composed. FI did not have
a department that provided Project Leaders. A Project Leader was selected based on the characteristics of the project or the engineer’s expertise and time schedule.

As the pilot study revealed, certain engineers at the three firms rotate among different development projects in the various business areas. FI, in its lifecycle, had several business areas. Therefore, some R&D engineers at FI rotated among the areas as needed. They might be involved in projects in several business areas. In particular, FI’s highly sought-after aerodynamic engineers rotated among the areas.

Although the analyses show that resources are managed using different control mechanisms, decisions about R&D activities involve other factors. At FI, managers reviewed the development projects to determine their status but had no defined or specified development processes with pre-determined review gates. The reviews emphasised the financial resource limits and the budget requirements.

However, the analyses show FI had a flexible attitude towards control mechanisms (e.g., budgets and project reviews). The informants said that if costs exceeded the budget, funds were simply re-allocated. The focus was on technology development rather than on finances. They said that projects sometimes had cost overruns, but because other projects were incomplete or had not started, such overruns were not a problem. Budgets were perceived more as financial guidelines than as financial straight jackets.

9.2.3 Vintage, Local Clothes or New, International Clothes?

The shared history of the three firms of this study leads to some important empirical insights. According to studies in economic research, acquisitions are often made to acquire resources (e.g., Dunning, 1993, 1998, 2000). A closer look at FI’s strategic resources reveals that many of their resources followed the three firms after the acquisitions (e.g., testing facilities and human resources with firm-specific knowledge). These resources were very important in helping the three firms achieve expected levels of performance and compete successfully in their markets. The analyses show the importance of the FI history to the three firms (see Barney, 1991).
The history of the three firms also reveals how FI’s strategy of R&D resource accessibility and management control transferred to the new environments. Figure 24 presents the relationship between management control and resource accessibility in the Integrated Resource Model.

<table>
<thead>
<tr>
<th>Internal Resource Accessibility</th>
<th>External Resource Accessibility</th>
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<tr>
<td>Explicit Management Control</td>
<td>Bureaucratic Resource Management</td>
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<tr>
<td>Implicit Management Control</td>
<td>Structured Resource Management</td>
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<td>Explorative Resource Management</td>
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<td></td>
<td>Flexible Resource Management</td>
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Figure 24: Integrated Resource Management model

The four quadrants in Figure 24 represent resource accessibility via internal or external resource accessibility strategies as linked to explicit or implicit management control mechanisms. It is important to remember that the boundaries of the quadrants are neither clear nor absolute. The boundaries merely define general ideas of the categories or ideal types of integrated resource management that might be found in R&D firms. The goal each strategy is competitive advantage.

**Bureaucratic Resource Management Strategy:**
An R&D firm in this quadrant achieves internal resource accessibility through explicit management control. Such firms focus on resource accessibility through acquiring and developing their own resources (i.e., by increasing internal resource stocks). They manage these resources using clearly formulated management control systems. Typically, a higher managerial level has controlling authority that ensures actions are structured and comply with rules. Alstom Power Växjö is in this quadrant.

**Structured Resource Management Strategy:**
An R&D firm in this quadrant achieves external resource accessibility through explicit management control. Such firms focus on resource accessibility, for example, by hiring and renting resources (i.e., by increasing external resource stocks) rather than by owning resources. A controlling authority ensures that actions are structured and comply with rules. Andritz Växjö is in this quadrant.
Flexible Resource Management Strategy:
An R&D firm in this quadrant achieves external resource accessibility through implicit management control. Such firms focus on resource accessibility, for example, by hiring and renting resources (i.e., by increasing external resource stocks) rather than by owning resources. However, informal and undocumented controlling authority across management levels neither prescribes nor prohibits actions. The focus is on flexibility in rule-making and decision-making, associated with taking less costly actions. Fläkt Woods Växjö is in this quadrant.

Explorative Resource Management Strategy:
An R&D firm in this quadrant achieves internal resource accessibility through implicit management control. Such firms have managers who acquire and develop their own resources (i.e., by increasing internal resource stocks). Informal and undocumented controlling authority across management levels neither prescribes nor prohibits actions. The focus is on exploration of rules that promote creative actions. FI adopted a similar strategy.

In Figure 25, FI is added to the model. The figure illustrates how the FI management used strategies to ensure resource accessibility and to provide management control.

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<th>Internal Resource Accessibility</th>
<th>External Resource Accessibility</th>
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<tr>
<td>Explicit Management Control</td>
<td>Alstom Power Växjö</td>
<td>Andritz Växjö</td>
</tr>
<tr>
<td>Implicit Management Control</td>
<td>Fläkt Industri</td>
<td>Fläkt Woods Växjö</td>
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</table>

Figure 25: The three firms in the Integrated Resource Management model

When FI was active as an R&D firm, its managers focused on developing its R&D strengths by taking an internal perspective. FI acquired resources that it used only in R&D. The aim was to increase value for its customers by introducing new products and processes, and to improve its existing technology. By focusing on the R&D activities, FI incurred substantial risks because successful outcomes from R&D activities are never guaranteed.

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With this internal perspective, FI was attuned to economic cycles. If customer orders for products and processes decreased, the resources invested in R&D would provide less return. Therefore, when the assumption in the FI analysis was that FI would have used explicit management control. However, the analyses did not support this assumption. The analysis of FI revealed that its managers ensured resource accessibility with implicit management control.

Focusing on the resource accessibility, Figure 25 also shows that Alstom Power Växjö is the only firm of the three firms that retained some of the FI “vintage clothes”. Alstom Power Växjö takes the same internal perspective that FI did. Andritz Växjö and Fläkt Woods Växjö, however, abandoned FI’s internal perspective.

There is no clear evidence whether Alstom Power Växjö imitated FI or coincidentally chose the same internal perspective. Nevertheless, the evidence does point to the fact that FI and Alstom Power Växjö acquired and developed resources intended to strengthen their R&D activities. The analyses of Alstom Power Växjö and FI show that the majority of their resources are essential R&D resources used to create and increase customer value. The informants claimed this strategy gave them an advantage over their competitors.

Except for this hint of “vintage clothes” retained, Figure 25 shows that after the acquisitions the three firms dressed themselves in new, international clothes as far as ensuring R&D resource accessibility and management control. For example, Andritz Växjö and Fläkt Woods Växjö both have a management resource strategy that takes an external perspective. Thus, they expand their resource base through various relationships. This external perspective gives them access to important resources (e.g., a testing facility) needed to conduct their R&D activities. This perspective also allows them to react rapidly to changes in the economy.

When it comes to the management control, Fläkt Woods Växjö alone of the three firms has retained some “vintage clothes” from FI. Although all three firms use control mechanisms, only Fläkt Woods Växjö has less directed management control. Whether the firm inherited this from FI or not is unknown.
9.3 Industrial Renewal

Figure 26 shows that the three firms have distanced themselves from FI and have adopted the new Integrated Resource Management strategies after the acquisitions.

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<th>Internal Resource Accessibility</th>
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<tr>
<td>Explicit Management Control</td>
<td>Alstom Power Växjö</td>
<td>Andritz Växjö</td>
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<tr>
<td>Implicit Management Control</td>
<td>Fläkt Industri</td>
<td>Fläkt Woods Växjö</td>
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Figure 26: Change in the Integrated Resource Management model

The Integrated Resource Management model shows that the managers of the three firms have moved towards a management strategy of greater explicit management control and an external perspective on resource accessibility. This strategy, which is not a carryover from FI, runs counter to the claims in previous studies on innovation that firms should use more implicit management control and an external perspective on resource accessibility.

The question is: Why did the three firms choose this strategy?

According to Barney and Arikan (2001, p. 38), strategy is “a firm’s theory of how it can gain performance within the markets it operates”. With this definition in mind, one answer to the question may be Industrial Renewal. Owing to industrial rationalisation, bureaucratisation, and specialisation in the air technology market, changes in the three firms’ management strategy were inevitable.

Mintzberg (1978) advised us that changes of strategies should be discussed in the context in which they originate. Therefore a brief review of Sweden’s industrial and economic is relevant at this point.

Sweden came rather late to the Industrial Revolution. FI was founded some 70 years after Sweden became an industrialised nation. Around the end of the 19th and the beginning of the 20th century, Sweden began the gradual change from an
agricultural society to a manufacturing society. Swedish firms were founded that processed raw materials and manufactured finished products.

In these years, often referred to as the second Industrial Revolution or Technological Revolution, factories electrified, goods were produced in mass, and the production assembly line was introduced. Manufacturing productivity increased, and economies grew. After World War II, from the mid-20th century until the early 1970s, the West continued to experience phenomenal growth. For Sweden, it was the golden age of industry. Growth Domestic Product (GDP) had rates in Sweden on average of 3.3% in 1951-1954, 3.4% in 1956-1960, 5.2% in 1961-1965, and 4.1% in 1966-1970. (See Magnusson, 2002)

After World War II, a major restructuring of industry occurred in Sweden (Magnusson, 2002; Segelod, 2011). In the 1960s Sweden enjoyed huge productivity gains and rapid growth in the metal, engineering, pulp and paper, and chemical industries. New machinery and new technologies were behind this growth. In fact, according to Magnusson (p. 411), technology explained 59% of the country’s industrial growth.

Among these industries, engineering perhaps made the most remarkable achievements. Engineering developments accounted for much of Sweden’s industrial growth from the 1950s through the 1960s. Quality engineering was required in the manufacture of most goods, from horseshoes to airplanes. Engineering of advanced and complex industrial parts supported the growth of other industries (Magnusson, 2002, pp. 420-421).

The rapid industrial expansion in Sweden began with a few, very large firms, concentrated in various sectors. By the 1970s, such firms had dominant industry positions. Among these firms were ASEA, STAB, SKF, Stora Kopparberg, and LM Ericsson. However, such concentration of firms did not prevent mergers and acquisitions (business-driven industrial re-organisation). As a consequence of these events, many firms changed their organisational form and even their name (Magnusson, 2002, p. 425).

Eventually, in the 1960s, competition from the United States and Japan reached Sweden. Because of high labour costs in Sweden, foreign products and processes, especially Asian, could be produced more cheaply. Sweden’s productivity stagnated. The 1971-1972 recession increased unemployment in Sweden, and the situation worsened with the oil crisis in 1978. After a recovery in the 1980s, the economic downturn in the 1990s was very severe.

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FI’s history tracks Swedish industrial history. The company was founded at the beginning of Sweden’s industrial revolution, and flourished after World War II in the country’s golden industrial age. Yet FI disappeared when the general economy declined in the 1990s.

The industrial landscape has changed extraordinarily since the years when FI was an important Swedish firm. The industry has gradually transformed, in large part because of the innovations and advances in R&D. Alstom Power Växjö, Andritz Växjö, and Fläkt Woods Växjö exist in a business environment far removed from the environment that FI profited from.

Today’s customers have new product and process demands (some of which are required by national and local environmental polices). These demands, which push R&D forward, result in new products and processes. Increased competition has also played a role. Consequently, the three firms have increased their focus on R&D.

Following the acquisitions of the three firms, their managements have increased the focus on rationalisation in which efficiency and economy are prioritised. Resource expenditures on employees and facilities are essential in R&D. However, the focus on cost reductions has escalated in recent years at the three firms. Their managers feel the pressure to adopt directed resource management, with its increase in managerial control, in order to produce the products and processes that customers want and are willing to pay for.

In the two decades since FI vanished, changes in the air handling market have forced the three forms to specialise in certain business areas. Fläkt Woods Växjö, for example, specialises in developing large axial fans for specific situations in which it is necessary to move large quantities of air. This strategy is consistent with the literature on strategic management that advises today’s firms to focus on business areas where its resources perform most effectively and have the best opportunity to create long-term value (e.g., Porter, 1996, p. 69).

Both Andritz Växjö and Fläkt Woods Växjö have become more adaptive to their changing economic environments. They have reduced their permanent work forces and hired outside consultants. This is a strategy that focuses on more efficient use of human resources (see Zack, 1999) as they develop their business areas (see Segelod, 2011, p. 15).
Finally, the simple fact of the acquisitions is a factor in the firms’ adoption of the Integrated Resource Management model. It is likely, if not unavoidable, that foreign owners and managers have new and different business strategies and perspectives. When the foreign multinational corporations acquired the three firms, change at the three firms was inevitable.

9.4 Chapter Summary

This chapter presents the Integrated Resource Management model that proposes alternative strategies for how R&D firms may access and manage their resources as they strive to be competitive.

The Integrated Resource Management model addresses decisions on (1) resource accessibility by either internal strategy (i.e., by increasing the firm’s internal resource stocks) or external strategy (i.e., by increasing the firm’s external resource stocks) and (2) the use of explicit or implicit management controls. The model proposes four resource management strategies: Bureaucratic Resource Management, Structured Resource Management, Flexible Resource Management, and Explorative Resource Management.

In the Bureaucratic Resource Management Strategy, resource accessibility is ensured by taking an internal perspective and adopting explicit management control. Resources are acquired, developed, and managed with clearly formulated procedures. A controlling authority at the upper management level oversees the structured actions.

In the Structured Resource Management Strategy, resource accessibility is ensured by taking an external perspective and adopting explicit management control. Resources are acquired, for example, by hiring and renting rather than owning resources. Controlling authorities across managerial levels ensure that actions are structured and comply with rules.

In the Flexible Resource Management Strategy, resource accessibility is ensured by taking an external perspective and adopting implicit management control. Resources are acquired, for example, by hiring and renting rather than owning resources. Controlling authorities across managerial levels use unexpressed mechanisms that neither prescribe nor prohibit actions. Flexibility in making rules means that less expensive actions are taken.
In the Explorative Resource Management Strategy, resource accessibility is ensured by taking an internal perspective and adopting implicit management control. Resources are acquired and developed internally. Controlling authorities across managerial levels use unexpressed mechanisms that neither prescribe nor prohibit actions. Flexibility in making rules means that less expensive actions are taken.

In its conclusion, the chapter places the three firms and FI (the firms’ “mother firm”) in the Integrated Resource Management model. The model shows how the firms’ resource management strategies changed following the break up of FI into the smaller, foreign-owned firms. The chapter discusses the reasons for these changes in the context of the changing industrial environment – the Industrial Renewal – in Sweden from the late 19th century to the early 21st century. As the Swedish economy changed, with the increased focus on specialisation and rationalisation, the three firms of this study also changed.
Chapter 10: CONCLUSIONS AND CONTRIBUTION TO THEORY AND PRACTICE

This thesis addresses an important business topic: competitive advantage at R&D firms. To equal, and even surpass, their competitors, R&D firms in today’s global markets must continually update their products and processes as well as create new products and innovate new processes. The global market is highly competitive, and a firm’s products and processes are vulnerable to changes in customer demands and needs as well as the fickleness of customer tastes. Technology also changes rapidly, and product life cycles are often quite short.

R&D firms that are insufficiently innovative risk losing markets and customers to competitors (Johne & Snellson 1988; Ottosson, 1999a, pp. 35-36; Ulrich & Eppinger, 2008). Therefore, R&D performance is an area of great interest among firms that compete in the global marketplace (e.g., Fredericks 2005; Brown & Eisenhardt, 1995). This study, which recognizes the complexities of R&D in its many facets – in particular, in acquiring and managing resources –focuses on the strategies R&D firms use to renew and develop their products and processes.

R&D firms that cannot keep up with their competitors – if they are not dissolved or bankrupted – may be sold and/or restructured. If they wish to avoid this fate, R&D firms, under the pressure of global competition, must find ways to create value for their customers.

That is the subject of this study as it seeks answer the following question: Which conditions are needed for R&D firms to stay competitive?

The thesis addresses this question by focusing on the internal aspects of firm competitiveness and by taking the view that resources, in their various forms, support an R&D firm’s competitiveness (Wernerfelt, 1984; Barney, 1991; Grant, 1991; Peteraf, 1993). R&D firms must have the ability to manage and exploit their resources using systems of managerial control (Penrose, 1959/2009; Grant, 1991; Helfat & Peteraf, 2003).
This chapter summarises the main findings of the research described in this thesis. It also describes the contribution of the Resource-based View (RBV) to theory and practice. The chapter concludes with suggestions for further research.

10.1 Strategic Resources and Resource Management in R&D firms

Previous studies describe the importance of resources in developing and improving products and processes (e.g., Brown & Eisenhardt, 1995; Del Canto & González, 1999; Verona, 1999; Krishnan & Ulrich, 2001). The analyses in this thesis (Chapters 7 and 8) show that a firm’s successful R&D results depend on which technical, financial, human, and relationship resources it has available and how it uses those resources.

An R&D firm uses its technical resources such as testing facilities to meet industry and customer requirements. Financial resources (sufficient cash flows) are used to support R&D development projects. Human resources (managers and other employees) are required in all the firm’s activities – production, research, and marketing, to name only three. Positive relationship resources (interactions with customers, suppliers, and society) are essential in today’s highly competitive global economy.

The RBV takes the position that some of a firm’s resources have more strategic value than other resources. These strategic resources are the key sources of a firm’s competitive advantage (e.g., Barney 1991; Conner, 1991; Peteraf, 1993). Using Barney’s (1991) VRIN framework, the thesis identifies and describes three Swedish firms’ strategic resources. These are the resources that have the VRIN attributes: Value, Rare, Imperfect Imitability, and Non-substitutable.

One conclusion of this research is that strategic resources such as test facilities (i.e., technical resources), people with technical, managerial, and marketing knowledge (i.e., human resources) and relationships with suppliers and customers (i.e., relationship resources) contribute to an R&D firm’s ability to conduct successful R&D activities and thus achieve and maintain a competitive position in its market.

This conclusion supports previous studies that emphasise that R&D firms need test facilities to support the in-house product testing, market testing, and pilot production conducted by technical experts (e.g., Kandemir et al., 2006). This
conclusion also supports studies that emphasise the importance of knowledge workers in R&D (e.g., Brown & Eisenhardt, 1995; Schriber & Löwstedt, 2014). These are people with marketing and technical knowledge who collaboratively create a base of R&D knowledge (e.g., Kandemir et al., 2006). In their relationships with customers and suppliers, such people advance the development of products and processes, and hence the success of their firms (e.g., Lüthje & Herstatt, 2004; Enkel et al., 2005; Ragatz et al., 1997).

A second conclusion of this research is that R&D firms can improve their performance and increase their competitive advantages with the use of complementary resources that lack some of the VRIN attributes. Complementary resources, while not qualifying as strategic resources, still contribute to firm success (e.g., Barney, 1995; Barney & Clark, 2007). R&D firms that join their strategic resources with their complementary resources in product and process activities profit by such linkages.

The case studies of the three firms in this research provide examples of the successful linkage of strategic and complementary resources. Human resources use information technology (in particular, software programmes) to make designs, calculations, and simulations. Such IT tools, while not strategic resources, are essential for executing projects and minimising costs. As Barney (1995) concludes, complementary resources may contribute to a firm’s competitive advantage when used in combination with other resources and capabilities.

Previous studies have not addressed complementary resources in depth, in particular how they contribute to competitive advantage when used with strategic resources. The research focus is primarily on the role of strategic resources. However, researchers have not rejected the theory of complementary resources.

A third conclusion of this research is that R&D firms’ histories may influence their performance and competitiveness. The RBV literature identifies firm history as a relevant isolating mechanism that promotes imitation (Barney, 1991, 1995; Barney & Clark, 2007, p. 60). As firms evolve, they develop resources influenced by their histories (Barney, 1995). This thesis analyses the effect of the three firms’ common history as sub-units of a larger firm prior to their acquisitions by multinational, foreign corporations. The three firms inherited tangible resources from the “mother firm” as well as the intangible resources derived from the employees, customers, suppliers, and work culture that transferred to the new firms.
The research identifies several of these legacies. One of the three firms retained the laboratory and workshops. All the firms maintained the previously established customer and supplier relationships. They also benefitted from the inherited brand name, reputation, and ways of working. Moreover, the three firms continued their activities in the same general location in southern Sweden where the “mother firm” was located. The firms formed a business cluster in Växjö, Sweden.

This sense of a common history, which is very strong in the three firms, poses a managerial problem for the multinational corporate owners. When the owners attempt restructuring and other changes to the three firms, the firms’ common history unites and supports them as they defend their positions in their business groups.

Critics have charged the RBV with both theoretical and methodological weaknesses (e.g., Priem & Butler, 2001a; Herrmann, 2005; Armstrong & Shimizu, 2007; Newbert, 2007; Lockett et al., 2009, Kraaijenbrink, Spencer, & Groen, 2010). One weakness is that the RBV has a static focus on firms’ resources (e.g., Teece et al., 1997). The claim is that this focus ignores firm processes and human actions (Whittington, 2002; Johnson, Langely, Melin, & Whittington, 2007, p. 9; Höglund & Sundström, 2011; Höglund, 2013). Thus, from a theoretical position, the contribution of this thesis is its focus on the resource management processes at the three firms. Thereby, the study sheds light on the black box of organising in Barney’s (1995) VRIN(O) framework.

It is not enough that R&D firms simply have resources. Resources must exploited to be of use (Aaker, 1989; Porter, 1991; Mahoney & Pandian, 1992; Amit & Schoemaker, 1993). Using various management control systems, firms can exploit their resources to greatest advantage (e.g., Barney, 1995; Barney & Mackey 2005, p. 10; Barney & Clark, 2007, p. 67; Barney & Hesterly, 2008, p. 90). The management control literature proposes various ways firms can best manage their resources strategically.

The thesis describes a framework of four systems that firms use to manage their resources. The framework is based on the Levers of Control (LOC) framework that Simons (1994, 1995) developed. This framework presents four control levels for the management of resources: Belief Systems, Boundary Systems, Diagnostic Control Systems, and Interactive Control Systems. These systems both promote and control innovation at R&D firms.
A fourth conclusion of this research is that the three firms manage their resources (i.e., Financial Resources, Technical Resources, Human Resources, and Relationship Resources) using these management control systems. Boundary Systems and Diagnostic Control Systems set constraints on technical and financial resources, and monitor compliance with those constraints. Boundary Systems and Diagnostic Control Systems prescribe and monitor the behaviour of the human resources. Belief Systems and Interactive Control Systems encourage and support creativity and learning among the human resources. Three of the four strategies of the Integrated Resource Management model indirectly influence the Relationship Resources.

A fifth finding of this research is that the three firms’ management control systems deal primarily with their own resources, and not with those of external actors. Moreover, most of their resource management focuses on the human resources (i.e., on human behaviour). This finding may, however, be a limitation because management control is chiefly directed towards ensuring that people in organisations act in appropriate and desired ways (e.g., Ouchi, 1977; Govindarajan & Gupta, 1985; Cardinal, 2001).

The sixth conclusion of this research is that managers should adopt an integrated view on resource management. The analyses in Chapters 7 and 8 conclude that successful R&D requires the combined contribution of a firm’s functions and resources. Management must combine its facilities, finances, and knowledge/skills using a mix of management control systems. Chapter 9 combines the analyses in Chapters 7 and 8 as the Integrated Resource Management model.


10.2 Practical Contributions
Practitioners working in R&D and others simply interested in the conduct of R&D will find the descriptions of the three R&D firms of historic as well as practical interest. The story of the three firms, all of which survived the break up

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of their “mother firm” following foreign acquisitions, is a remarkable story of business survival and adaptation. In some respects, the story is very likely unique, especially in the Swedish business environment.

More specifically, the findings of this research highlight that strategic and complementary resources are sources of competitive advantage, especially when used and managed in combination.

The findings also demonstrate how Belief Systems, Boundary Systems, Diagnostic Control Systems, and Interactive Control Systems support practitioners in the management of their resources. The Integrated Resource Management model that may guide practitioners in their R&D activities.

10.3 Future Research Directions

The primary method of data collection for this research was the face-to-face interview. The secondary method was archival research. Other data collection methods may elicit other findings on the broad subjects analysed in this thesis. One suggested method is observation. Researchers who are allowed to observe meetings, formal and informal, may be able to give us a better understanding of how people at various levels and from various organisations manage resources at R&D firms.

Foreign, multinational corporations who acquired the three firms did not remove them from the location of the “mother firm” in southern Sweden. An interesting research project would be to make a comparative study of R&D firms in other countries. A possible focus of such a project could be the effect, if any, that geographic location has on the firms’ competitiveness.

The three firms in this thesis provide an understanding of handling products and processes to the commercial sector. A suggestion for further research is to make a similar study of R&D firms that serve the retail sector, for example, pharmaceutical firms.

This thesis analyses the three R&D firms that are foreign-owned divisions of multinational corporations. Thus, the research was conducted from the perspective of the three firms – their histories, their managers and employees, and their culture, capabilities, and goals as they access and manage their resources. To some extent, this gives us a one-sided picture. It would be interesting to study
the three firms from the perspective of their owners. From a resource management perspective, the research question might be phrased as follows: How do owners influence their R&D subsidiary firms to stay competitive?
REFERENCES


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Appendix 1: Product Development Process

Product development is an interdisciplinary process that requires contributions from all areas in an organization (Ulrich & Eppinger, 2008). It involves different aspects of the organisation and different functions of the managers who need to draw them together to ensure success (Barclay & Benson, 1990). The process involves a series of activities that are usually led by different departments or teams, each with its own structure, skills, people, and resources (Barclay & Benson, 1990; Ulrich & Eppinger, 2008). It is common to divide the product development process into different phases or steps in order to structure the activities that must be completed to produce a product.

Figure 27: Generic Product Development Process (inspired by Ulrich & Eppinger, 2008)

Figure 27 depicts the generic product development process model for different types of products (e.g., market-pull, technology-push, platform, process-intensive, and customised and high-risk products). Each phase is usually followed by a review or gate that confirms that the phase is completed and determines if the project should proceed. This generic product development process is divided into the following six phases: planning, concept development, system-level design, detailed design, testing and refinement and production ramp-up.

In the Planning phase, approval for the project and the launch of the product development are approved. This phase is linked to advanced research and technology activities. It begins with corporate strategy, including an assessment of technology development and market objectives. It is common to develop products in a project setting (Johansson, 2008) in which the project’s mission statement is the output of the Planning phase. The phase involves specification of the target market for the product, business goals, key assumptions, and constraints.

In the Concept Development phase, product concepts are generated and evaluated. One or more concepts are selected for further development and testing. A concept includes a description of the form, function, and features of a product. This description is usually accompanied by a set of specifications, an analysis of competitive products, and the economic justification for the project. This phase in-
volves identification of customer demand, target specifications, concept generation, concept selection, concept testing, project planning, economic analysis, bench marketing of competitive products, modelling, and prototyping. (Ulrich & Eppinger, 2008)

In the *System-Level Design* phase, the product architecture is designed and the break down of the product into sub-systems and components is completed. Typically, the assembly scheme for production is finalised in this phase. This includes designing each product’s geometric layout, defining the functional specification of each product’s sub-systems, and preparing process flow diagrams for the final assembly. (Ulrich & Eppinger, 2008)

In the *Detailed Design* phase, complete specification of the geometry, materials, and tolerances of all unique parts in the product are designed. The phase also includes identification of the standard parts to be purchased from suppliers. A process plan is presented in this phase, and tooling is designed for each part to be fabricated in the production process. A control document for the product is completed that includes drawings of each product part, production tooling, specification of the purchased parts, and process plans for fabrication and assembly. Two critical issues are addressed in this phase. The first issue is the production cost; the second issue is the robustness of the product’s performance. (Ulrich & Eppinger, 2008)

In the *Testing and Refinement* phase, construction and evaluation of the pre-production version of the products are tested. Prototypes are built to test whether the product design is functional and whether the product will meet the customers’ needs. Customers may test prototypes in their own environments. An evaluation is made to determine if further refinement, involving engineering changes, is needed. In the *Production Ramp-up* phase, the production employees are trained, and the remaining problems in the production process are solved (Johansson, 2008 p. 11). At some point, a transition from the Production Ramp-up to ongoing production takes place. This transition occurs gradually (Ulrich & Eppinger, 2008, pp. 14-15).

Researchers generally agree on these phases of the product development process. Prior research concludes that the successful completion of all development phases is usually a crucial determinant of new product success (Cooper & Kleinschmidt, 1986). However, for some incremental products, some phases in the product development process are often skipped (Ibid.) because the product is a direct extension of prior knowledge (Song & Montoya-Weiss, 1998).
### Appendix 2: Overview of Pilot Study’s Interviews

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# Appendix 3: Overview of Study’s Interviews

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Appendix 4: Interview Guide/Pilot Study

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○ Position  
○ Interview Duration  
○ Location  
○ Allowed to Record  
○ Presentation of myself  
○ Introducing the study |
| Background information on informant | ○ Educational background  
○ Previous experience  
○ Prior experience at the firm |
| Organisation                  | ○ Group  
○ Operations in Sweden and Växjö  
○ Business idea and objectives  
○ Organisation structure  
○ Organisation size  
○ Knowledge structure of the firm |
| Product                       | ○ Business areas/products/processes  
○ Applications  
○ Market  
○ Customers  
○ Competitors  
○ Development |
| Product Development           | ○ How was the R&D organised?  
  ▪ Project  
  ▪ Team composition and configuration  
  ▪ Decision-making and Responsibility  
○ How was the R&D conducted?  
  From start to finish  
  ▪ Objective  
  ▪ Time schedule  
  ▪ Resource availability and allocation  
  ▪ Evaluation and Measurements  
  ▪ Feedback  
○ Involvement of others  
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## Appendix 5: Interview Guide/Overall Study

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○ Presentation of myself  
○ Introducing the study |
| **Background information on informant** | ○ Educational background  
○ Previous Experience  
○ Prior experience at the firm |
| **Organisation**       | ○ Group  
○ Operations in Sweden and Växjö.  
○ Business idea and objectives  
○ Organisation structure  
○ Organisation size  
○ Knowledge structure of the firm |
| **Product**            | ○ Business areas/products/processes  
○ Applications  
○ Market  
○ Customers  
○ Competitors  
○ Development |
| **Product Development**| ○ How was the R&D organised?  
  ▪ Project  
  ▪ Team composition and configuration  
  ▪ Decision-making and Responsibility  
○ How was the R&D carried out?  
  From start to finish  
  ▪ Objective  
  ▪ Time schedule  
  ▪ Resource availability and allocation  
  ▪ Evaluation and Measurements  
  ▪ Feedback  
○ Involvement of others  
  ▪ Group  
  ▪ External actors  
○ Connection to customer projects |
| **AB Svenska Fläkt Fabriken & Fläkt Industri** | o Prior experience at SF/FI  
o Experience of the Acquisition  
o Changes  
  ▪ Organisation  
  ▪ Product  
  ▪ Product Development |
| **Additional Information** | o Available archival data  
o Other potential informants  
o Return to contact informant  
  ▪ Review the transcripts |
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