Adapting Manufacturing Strategy to Industrial After-Sales Service Operations
Previous publications in the PROFIL series:


Adapting Manufacturing Strategy to Industrial After-Sales Service Operations
PREFACE

The objective of the PROFIL series is to provide information on research and other developments within the field of production economics by associates of Linköping Institute of Technology. Production economics is basically an engineering discipline, focussing on topics treating the interface between engineering and management and is therefore interdisciplinary in nature. It attempts at a two-way scientific integration; on the one hand to apply economic knowledge and reasoning to engineering and manufacturing problems, on the other hand, to utilise the arsenal of existing mathematical and quantitative engineering methods for analysing economic and managerial issues. It focuses various allocation problems, in particular on the optimal use of productive resources within manufacturing and other industries. It encompasses developments in theory and application, wherever engineering and technology meet the managerial and economic environment in which industry operates. From the economic science perspective, the methodological approach is based on the theory of production, a branch of microeconomic theory, and on methods of production and operations management. During the last few decades this theory has been integrated with methods from operations research and management science. The quantitative economic approach has thereby in a natural manner obtained a firm footing within the field.

Among the multitude of problems covered by this subject area can be found the development of principles for operations management on different levels and with varying scope. The operations under study can be related to manufacturing, supply chains, services, and other areas. Also, principles and procedures for investment planning and financial decisions are included. In this fascinating field of research, a host of interesting and intricate problems are awaiting solution, and their practical implementation may often be just round the corner. The field is also experiencing considerable attention today – from the academic as well as the practical point of view. The competitive edge of many world class companies is nowadays gained through operations excellence, creating competitive advantages through proper applications of operations strategy principles and improvement initiatives concerned with e.g.
lead times, inventory, and flexibility. Education and research in these areas are therefore important and rewarding, perhaps more so now than ever before.

This twenty-fourth publication in the PROFIL series entitled “Adapting manufacturing strategy to industrial after-sales service operations” has been written by Pontus Johansson who is presenting it as his doctoral thesis in Production Economics at Linköping Institute of Technology.

Linköping in January 2006
Jan Olhager
Professor
Head of the Department of Production Economics
FOREWORD

It has been a process running for almost exactly five years, and now that the process finally seems to be approaching its end, the physical item produced in the process is what’s in your hand. While this thesis is the only tangible artefact summarizing these past years, interaction with colleagues, teaching students, and discussions with friends have been an important part of the work. This intangible output, the service content, is probably the most interesting and valuable contribution of the years passed. It is thus my hope that some of you students, colleagues and friends have understood or realised something new, in one way or another, by having been involved in my work with this thesis. At least, you have helped me realising what is important and not, and for that I want to express a very sincere thanks.

My gratitude goes especially to some of the doctoral students I have had the fortune to work with in various ways during the years passed, so to Selldin, West, Rudberg, Bengtsson, Persson, Saccani, Hallgren, and Turano: it has been a pleasure! To professors Olhager and Perona: the guidance has been appreciated, and I hope I haven’t been too much trouble for you (some, yes, but not too much…). A special thanks also for the fantastic hospitality received in Brescia. To family and close friends, the laughs and support received really can not be valued enough. And when it comes to laughs and support, Anna certainly deserves the most gratitude, and I promise to try to return as much as I can now that life returns to a not-dissertation-writing state...

Time to go skiing!

Finspång, January 2006

Pontus Johansson
**DISSERTATION OUTLINE**

This publication is entitled *Adapting manufacturing strategy to industrial after-sales service operations*, and is written as a doctoral thesis at the Department of Production Economics at Linköping Institute of Technology. The dissertation is divided into two parts. The first is an introductory part, which contains the theoretical foundation. This first part also contains a summary of the included papers and the main research contribution. The second part is the six separate research papers, as listed below, which constitute the full content of the dissertation.

**Paper 1**


This paper was originally presented at the 12th International Working Seminar on Production Economics in Igls, Austria, February, 2002.

**Paper 2**


Earlier work related to this paper has been presented at the 1st EurOMA and POMS Joint Conference in Como, Italy, June, 2003 and at the 13th International Working Seminar on Production Economics in Igls, Austria, February, 2004.

**Paper 3**


This paper is submitted for publication in *Omega*. An earlier version of this paper was presented at the 9th annual meeting of the Informs

**Paper 4**


This paper is considered for a special issue of the *International Journal of Production Economics*, as a selected paper from the 18th International Conference on Production Research in Salerno, Italy, August, 2005 where a short version of this paper was presented.

**Paper 5**


This paper was presented at the 12th European Operations Management Association Conference in Budapest, Hungary, June, 2005.

**Paper 6**


Presented at the 14th International Working Seminar on Production Economics in Innsbruck, Austria, February, 2006.
CONTENT

1 INTRODUCTION ........................................................................................................ 1

2 FRAME OF REFERENCE ...................................................................................... 4
  2.1 The goods to service continuum ............................................................ 4
  2.2 Manufacturing strategy .......................................................................... 7
    2.2.1 Competitive priorities ................................................................... 8
    2.2.2 Decision categories ......................................................................... 10
    2.2.3 Process technology ......................................................................... 11
    2.2.4 Capacity ......................................................................................... 13
    2.2.5 Facilities ........................................................................................ 16
    2.2.6 Vertical integration ......................................................................... 16
  2.3 After-sales and service operations management .................................. 17
    2.3.1 Content of service operations management .................................. 17
    2.3.2 Classifying services and service processes .................................. 19
    2.3.3 Industrial after-sales service ......................................................... 19

3 RESEARCH DESIGN ............................................................................................ 23
  3.1 Scope ......................................................................................................... 23
  3.2 Objective .................................................................................................... 23
  3.3 Method ....................................................................................................... 24
  3.4 Research questions .................................................................................... 24
  3.5 Co-author statement ................................................................................ 26

4 SUMMARY OF PAPERS ..................................................................................... 28
  4.1 Paper 1: Industrial service profiling: Matching service offerings and processes .................................................. 28
  4.2 Paper 2: Linking product-process matrices for manufacturing and service operations ........................................... 29
  4.3 Paper 3: Long-term capacity management for integrated manufacturing and service operations .................. 30
  4.4 Paper 4: Configuration of the after-sales service supply chain - an empirical research .................................. 31
  4.5 Paper 5: The after-sales service, aligning supply chain configuration with strategy - evidence from the household appliance industry ................................................. 32
  4.6 Paper 6: Adapting manufacturing strategy to the increased service content of products ............................... 34
5 CONCLUSION.................................................................................................................. 35
5.1 Research contribution ............................................................................................. 35
5.2 Future research ........................................................................................................ 36
5.3 Reflections ................................................................................................................. 38

REFERENCES .......................................................................................................................... 39

PAPERS

Paper 1: Industrial service profiling: Matching service offerings and processes
Paper 2: Linking product-process matrices for manufacturing and service operations
Paper 3: Strategic capacity decisions for service operations
Paper 4: Configuration of the after-sales service supply chain – an empirical research
Paper 5: The after-sales service, aligning supply chain configuration with strategy - evidence from the household appliance industry
Paper 6: Adapting manufacturing strategy to the increased service content of products
1 Introduction

For basically any company the goal is to maintain long term profitability, in order to secure shareholder value. By integrating the fields of engineering and economics in an interdisciplinary way, Production Economics provides tools and methods that are applicable to managerial problems, with an aim to ensure the economic needs of companies. For many manufacturing companies after-sales services are a natural part of the performed activities, and as such should contribute to the overall goal of profitability. The needs and characteristics of these after-sales services are here connected to the framework of manufacturing strategy, in order to find production economic solutions to problems raised in manufacturing companies with a significant share of their operations being involved in the supply of after-sales activities.

The original reason for starting this research was the background of the author. Having come in contact with various after-sales service activities within the companies Kvaerner, ABB and SKF during my time studying for a master of science, I was intrigued by basically two things. The first was the usually very good profitability of these business areas of the companies, even at times when industry in general was struggling. This was a very appealing characteristic of the after-sales services, as it is almost always funny to be part of a winning – or in this case profitable – team. The second thing though was something that gave a more mixed feeling, and this was the lack of refinement in the business models, and also the lack of both theoretical and empirical guidelines for managing the after-sales service part of operations. So while working at what was then named ABB-ALSTOM Power, today divided into ALSTOM and Siemens, the opportunity to enter a doctoral program at the Department of Production Economics emerged. To achieve a counterweight to this starting point as a practitioner, the thesis has a theoretical aim and its results are found through deductive reasoning using existing theories. This reasoning may however unintentionally be coloured by the background of the author, as stated above.

Although questions concerning the management of industrial after-sales services was the main reason for initiating this research, it should be noted that services in general are becoming of increasing
importance to companies and society. The continuous change in the world has led to a situation where traditional industry no longer is the major contributor to employment and economy in the western countries. Instead, service activities are at an all time high, contributing to more than 70% of both gross domestic product and share of employment (see e.g. Fitzsimmons and Fitzsimmons, 1998, Hope and Mühlemann, 1997, and Schmenner, 1995). Considering employment, services are in the lead while agricultural activities are at an all time low, only occupying a few percent of the workforce, and manufacturing is still making a fairly large contribution with commonly around 20%. Figure 1 shows how employment has shifted in the U.S. economy over the past 150 years, highlighting the importance of services.

![Figure 1: Employment shares by economic sector in the U.S.](image)

It is thus undeniably a fact that service activities of various kinds play a crucial role in society. This increase in service activities has created industries that are not only manufacturers, but rather suppliers of both goods and services. Production economics as a research area has as one of its tasks to analyse managerial issues in an industrial context, and as industry is becoming more and more service oriented, research on issues relating to a combination of manufacturing and service operations is called for. In this thesis specifically, selected parts of the manufacturing strategy framework are analysed and adapted to better suit companies who consider
their after-sales services to be of strategic importance. This kind of adaptation should also be seen as contribution to the process of transforming the manufacturing strategy framework into a more general operations strategy. Such a transformation is undeniably taking place in academia, as the term operations strategy is taking over from the traditional manufacturing strategy in a way that has been very noticeable over the five years that has been the life span of this research project.

The layout of the introductory part of this thesis is as follows. In the second chapter, a theoretical frame of reference is introduced which starts by discussing products as a goods-to-service continuum, followed by an introduction of selected parts of the manufacturing strategy framework, and finally an overview of after-sales and service operations management research. The third chapter deals with the research design, specifying the scope and objective of the thesis. Further, the method is discussed, and research questions are specified. In chapter four, the individual papers constituting the second part of this thesis are summarized. Finally, chapter five concludes the research contribution, and it also contains directions for future research as well as a reflection upon the work presented in this thesis.
2 Frame of reference

The purpose of this chapter is to give the reader an introduction to the research foundation which the individual papers of the thesis rests upon. The theoretical frame of reference presented here is divided into three parts. First is a part discussing the differences and similarities between goods and service, and the use of the term product. The second part is devoted to the basic concepts of manufacturing strategy, and the third to service operations management, with a specific focus research related to after-sales services.

2.1 The goods to service continuum

A common denominator within service operations and service management literature is a clarification and motivation why service is an area that needs to be treated separately from traditional goods manufacturing. Based upon Sasser et al. (1978), Haksever et al. (2000) claim that the four primary characteristics of a service are intangibility, inseparability, perishability and variability. A similar view is held by Metters et al. (2003), who claim that what separate services from goods is intangibility, simultaneous production and consumption, proximity to customer, and that inventory cannot be held. Slight differences can be found between different works, but a summary of characterising differences is presented in Table 1. These differing characteristics are adapted from Grönroos (2001), Fitzsimmons and Fitzsimmons (1998), Schmenner (1995), Johnston and Clark (2001), and Finch and Luebbe (1995).

A pure service product can thereby be seen as something untouchable, which only exists while it is being supplied, and that is an exchange between two actors. Operations management deals with the transformation process of turning inputs into outputs, traditionally considering the output to be a good (Hope and Mühlemann, 1997). In a similar way service operations management also deals with the transformation process, but with consideration taken to the specifics of services, compared to operations’ original manufacturing focus. (See e.g. Hope and Mühlemann, 1997).
Table 1. Characteristics separating services from goods  
(Based on Grönroos, 2001; Fitzsimmons and Fitzsimmons, 1998; Schmenner, 1995; Johnston and Clark, 2001; and Finch and Luebbe, 1995).

<table>
<thead>
<tr>
<th>Product as good</th>
<th>Product as service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tangible</td>
<td>Intangible</td>
</tr>
<tr>
<td>Homogeneous</td>
<td>Heterogeneous</td>
</tr>
<tr>
<td>Production and distribution separated from consumption</td>
<td>Production, distribution and consumption simultaneous processes</td>
</tr>
<tr>
<td>A thing</td>
<td>An activity or process</td>
</tr>
<tr>
<td>Core value produced in factory</td>
<td>Core value produced in buyer-seller interactions</td>
</tr>
<tr>
<td>Customers do not (normally) participate in the production process</td>
<td>Customers participate in production</td>
</tr>
<tr>
<td>Physical/capital entry barriers</td>
<td>Easy entry</td>
</tr>
<tr>
<td>Capital intensiveness</td>
<td>Labour intensiveness</td>
</tr>
<tr>
<td>Many output related measurements possible</td>
<td>Difficult to measure, output is perceived by the customer</td>
</tr>
<tr>
<td>Time disconnected through inventory</td>
<td>Real-time</td>
</tr>
<tr>
<td>Can be resold</td>
<td>Difficult to resell</td>
</tr>
<tr>
<td>Can be kept in stock</td>
<td>Cannot be kept in stock</td>
</tr>
<tr>
<td>Transfer of ownership</td>
<td>No transfer of ownership</td>
</tr>
</tbody>
</table>

In this thesis a combination of good and service is investigated. That combination is industrial after-sales services, *i.e.* the supply of after-sales services, including tangibles such as spare parts and consumables, related to the maintenance of industrial goods. An after-sales service is not a good, nor should it be seen strictly as a service. Rather, it should be seen as a product, under the presumption that a product may consist of both goods and service properties and characteristics, simultaneously. Such a view of what constitutes a product can also be found through constructs such as the extended product, or the service product (Nordin, 2005b), where the product offered is a combination of goods and services. In these products, the distinction between goods and service is getting increasingly difficult to point out, or as stated by Schmenner “*the line that separates manufacturing and service has become more and more blurred,*” (Schmenner, 1995, p. 2). This kind of blending of goods and services is shown in Figure 2, based on Oliva and Kallenberg (2003). They find that traditional goods manufacturers are moving away from the leftmost part of the figure, and have started to supply to
their customers an increasing share of services. This transformation of traditional manufacturers becoming service providers is also confirmed by Brax (2005), who find a number of challenges these companies have to deal with, e.g. in producing, marketing and delivering this service content.

![Figure 2: The goods-service continuum (based on Oliva and Kallenberg, 2003)](image)

To reach the stage of delivering an after-sale service, which is the kind of product considered in this thesis, an original sale must have taken place. This thesis deals with the case where the original sale consists, to at least some extent, of a manufactured industrial good. Hitomi (1990) provides a historical view of the term manufacturing, which stems from the Latin term manu factum (made by hand). As a comparison to manufacturing, Hitomi (1990, originally from Tajima, 1910, p. 1) describes production as the creation of utility, including both goods and services. Manufacturing, on the other hand, is the production of tangibles, i.e. the goods part of production. Thus manufacturing is the creation of utility in the form of a tangible good, with characteristics as listed in the left column of Table 1.

While perhaps not always fully aware of it many manufacturing companies supplying industrial goods have been service suppliers for a long time, for example by delivering various after-sales services to their customers. These after-sales services includes tangibles such as spare parts, but also intangibles such as inspections and training, and are related to the maintenance and proper use of the underlying industrial goods. These after-sales services have traditionally been seen as a cost generator and a “necessary evil” (Lele, 1997), but a change of this view is taking place. As shown in Figure 2, this has created companies that make products consisting of both service and goods content, and that in
many cases there is a transformation towards an increased share of service content.

A general note regarding the word service should be made, since the word can be seen as basically one of two things. It can be seen either as a customer offering, for example a haircut or a meal at a restaurant, or as the level of perceived quality in a business transaction, as in “the service we get from company X is always very good”. In this thesis the first view of service, a customer offering, is used.

2.2 Manufacturing strategy

In order to succeed with the goal of creating value through long-term survival and profitability, manufacturing companies continuously make decisions regarding future events, consciously or not. Under the premise that these decisions are deliberate and thought through, they constitute the company’s strategy. Thus a company’s strategy is the path it takes to reach its goals. Since the start by Skinner (1969), manufacturing strategy has evolved into a well-defined research area, with generally accepted theories and numerous textbooks for teaching the subject (e.g. Hayes and Wheelwright, 1984; Stonebraker and Leong, 1994; Hill, 1995, 2000; Slack and Lewis, 2002; and Hayes et al., 2005). Common content in these books are chapters regarding capacity, facilities, planning and control, and quality strategies. As the research field has evolved, the word operations is increasingly being used instead of manufacturing; in the following subchapters both words are used, in order to try to stay true to the references which are being used. However, given the evolution of the manufacturing strategy framework, the term operations strategy is the most appropriate in the view of the author. This is based on an increasing attention to service specific questions being handled in the books listed above, especially so in Slack and Lewis (2002) and Hayes et al. (2005), in which the word operations is used instead of manufacturing. Slack and Lewis (2002) explicitly state that they make a step from manufacturing only to a more generalised operating environment, covering both goods and service operations. As such, Slack and Lewis (2002, p.14) define operations strategy as: “the total pattern of decisions which shape the long-term capabilities of any type of operation and their contribution to overall strategy”. This indicates that a manufacturing strategy would be
defined by substitute the words “of any type” to “a manufacturing” in the definition. In a similar fashion, Hayes et al. (2005, p.33) define operations strategy as “a set of goals, policies, and self-imposed restrictions that together describe how the organization proposes to direct and develop all the resources invested in operations so as to best fulfil (and possibly redefine) its mission”.

In Figure 2 a common model of the content of a manufacturing strategy is presented (Leong et al., 1990). While this thesis focuses on the content of the decision categories in the model, an introduction to the competitive priorities is also given. Further, there is commonly a distinction between the content of manufacturing strategy and the process of manufacturing strategy. This thesis aims at contributing to the content of manufacturing strategy, which is also the case for most research on manufacturing strategy; according to a study by Dangayach and Deshmukh (2001) as much as 91 % of the manufacturing strategy literature they classify is focussed on content related questions.

2.2.1 Competitive priorities

Porter (1980) sees two basic paths for competitiveness: cost leadership or differentiation. Leong et al. (1990) on the other hand find that within manufacturing there are five dimensions of competitive priorities, cost, quality, delivery performance, flexibility, and innovativeness. Miltenburg (1995) wishes to add a sixth competitive priority, performance, to the list. However, there are strong similarities between quality and performance as defined by Miltenburg (1995), and for ease of comparison the five
competitive priorities proposed by Leong *et al.* (1990) are used here. The set of five competitive priorities and their manufacturing implications, as presented in Table 2, is summarized from Leong *et al.* (1990) and Miltenburg (1995).

Within the competitive priorities, trade-offs normally have to be made. In a competitive market, no company can normally be in front on all areas. The point of the priorities is instead to help in the task of positioning a company with an advantage versus its competitors.

**Table 2. The set of competitive priorities.**

<table>
<thead>
<tr>
<th>Competitive priority</th>
<th>Manufacturing implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>Keeping track of costs, and distribute it properly on the various products.</td>
</tr>
<tr>
<td>Quality</td>
<td>Ensuring that the product and its process perform and conform to specification.</td>
</tr>
<tr>
<td>Delivery performance</td>
<td>Dependable (on time) and fast (short lead-time) delivery of products, stock availability.</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Ability to handle volume and product mix changes, machine and workforce-related</td>
</tr>
<tr>
<td>Innovativeness</td>
<td>Time-to-market, how fast new products or processes can be implemented.</td>
</tr>
</tbody>
</table>

On a “high level” the competitive priorities can be said to constitute a manufacturing strategy. To create a more manageable strategy though, the priorities have to be broken down into smaller pieces, such as the decision categories presented in section 2.2.2. In order to prioritise among the competitive priorities, the concept of order winners and qualifiers can be used (Hill, 1995). On the one hand there are the order-winners for a product, *i.e.* the characteristics that make a company receive a new order. Order-qualifiers, on the other hand, are necessary to be able to compete in a market at all. Among the order-qualifiers, order-losing sensitive qualifiers can usually be found. These are characterised by the fact that they are critical for the customer, and if missed it will undoubtedly lead to a lost order. To separate order-winners and qualifiers, Hill (1995, p. 46) states that: “To provide qualifiers, companies need only to be as good as competitors; to provide order-winners, they need to be better than competitors”.

9
The purpose of evaluating a company’s order-winners and qualifiers is to determine a foundation for a manufacturing strategy. As such they can be seen to have a strong link to the competitive priorities presented in Table 2. Having a manufacturing strategy that does not support the company-specific order-winners and qualifiers could be more damaging than helpful. Determining order-winners and qualifiers is not a one time task, but rather has to be done continuously, since market demands change over time and together with that the order-winners and qualifiers. To determine which criteria that are important Hill (1995) points out that the marketing function of the firm should be involved in deciding on order-winners and qualifiers, and thus also in developing the manufacturing strategy.

Manufacturing is not always the part of a company having the biggest impact on order-winners and qualifiers. The order-winning and qualifying criteria are therefore divided into two groups, depending on whether they are manufacturing-related or not (Hill, 1995). Directly manufacturing related criteria are among others price, delivery precision, and quality, while e.g. after-sales support and brand name are not directly related manufacturing according to Hill. As argued in this thesis though, after-sales services are taking an important role in the operations of traditional manufacturing firms, and thus after-sales services have an important impact on the operations strategy.

2.2.2 Decision categories

Rudberg and Olhager (2003) make a summary of a number of different proposed frameworks regarding decision categories in manufacturing. Their summary is an update of the work done by Leong et al. (1990). The number of decision categories varies slightly between different authors, the ones chosen for Table 3 can be said to be one representative set, at least with respect to the structural decision categories. For the infrastructural categories, there is some variation among authors; Hayes et al. (2005) e.g. add quality systems, human resources, and resource allocation systems to the list in Table 3. The bifurcation into structural and infrastructural categories is taken from Hayes and Wheelwright (1984), who are also the first to list a more “complete” set of manufacturing strategy decision categories. Using the words structural and infrastructural may at
first seem counter-intuitive, but is explained by Hayes et al. (2005). Structural refers to physical categories, tangibles, which require a typically large capital investment and may thus be difficult change or alter once in place. The infrastructural categories determine how the organisation’s systems, policies, and practices will be managed, and while not always requiring large capital investments, altering or development of these categories can be just as difficult and time-consuming as the structural ones.

The focus of this thesis is the structural decision categories, process technology, capacity, facilities, and vertical integration. These four categories are treated individually in the subchapters 2.2.3 – 2.2.6, whereas the infrastructural decision categories are not given any further attention.

### Table 3. Example of manufacturing strategy decision categories.

<table>
<thead>
<tr>
<th>Decision Categories</th>
<th>Type of sub-decisions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structural</strong></td>
<td></td>
</tr>
<tr>
<td>Process technology</td>
<td>Process choice, technology, integration</td>
</tr>
<tr>
<td>Capacity</td>
<td>Amount, timing, increment size</td>
</tr>
<tr>
<td>Facilities</td>
<td>Size, location, specialisation and focus</td>
</tr>
<tr>
<td>Vertical integration</td>
<td>Direction, extent, balance</td>
</tr>
<tr>
<td><strong>Infrastructural</strong></td>
<td></td>
</tr>
<tr>
<td>Performance</td>
<td>Measurements, methods of measures, feedback</td>
</tr>
<tr>
<td>measurement</td>
<td></td>
</tr>
<tr>
<td>Organisation</td>
<td>Design, human resources, competence development</td>
</tr>
<tr>
<td>Introduction of new</td>
<td>Rate of introduction</td>
</tr>
<tr>
<td>products</td>
<td></td>
</tr>
<tr>
<td>Manufacturing</td>
<td>System design, decision support, system integration</td>
</tr>
<tr>
<td>planning and control</td>
<td></td>
</tr>
</tbody>
</table>

### 2.2.3 Process technology

When deciding upon a new manufacturing process it will result in an often considerable investment and it is therefore important that it satisfies both business and technical perspectives (Hill, 1995). Which types of products to produce and their various characteristics have to be analysed thoroughly in order to make the right decision. The
choice of process must also reflect the market in which the product is competing, with respect to volume and range of variation.

To be able to choose a suitable process it is necessary to know which choices of different processes that are available. Hill (1995, 2000) lists five different generic types of process choices, while Hayes and Wheelwright (1979a, 1979b) only list four. Another perspective is that of Schroeder (1993), who differentiates between three types of processes. What is important though is not the number of generic processes, but the fact that these processes span between the extremes of project and continuous process, exemplified by e.g. building a cruise ship, and running a petrochemical plant, respectively.

The various processes available to choose from have their own characteristics regarding market, production planning, costs and organisation. To aid in the choice of process Hayes and Wheelwright (1979a, 1979b) developed a matrix that links the different processes with a product’s life cycle, as presented in Figure 4. The concept of matching processes with products is widely accepted, and further worked and commented on by e.g. Spencer and Cox (1995), Safizadeh et al. (1996), McDermott et al. (1997), and Ahmad and Schroeder (2002).

![Figure 4. The product-process matrix. (Adapted from Hayes and Wheelwright, 1979a)](image-url)
The diagonal in Figure 4 is the normal position of a competitive company (Hayes and Wheelwright, 1979a, 1979b). To find a competitive advantage a company can choose a process strategy off the diagonal. If the company is not aware of the implications of that choice it can be risky, due to the higher vulnerability of the company.

Hayes and Wheelwright (1979a, 1979b) show how a product’s evolution in its life cycle changes the demand on manufacturing. At first when volumes are low, flexibility is necessary, and can be found in the upper left corner. Later on, when volumes are higher and competition can be expected, manufacturing must support low costs, as found in the lower left corner. These thoughts are adopted by Hill (1995, 2000), who points at these characteristics when volumes increase, but without involving the product life cycle.

Hill (1995, 2000) has developed the product profiling concept as a tool to allow for a multi-factor analysis of the match between products and processes. The basic purpose of this framework is to normatively describe and prescribe how to best design a production process for a certain set of products. Product profiling allows for a situation-specific selection of the characteristics that can be used to describe the nature of products as well as processes. The usefulness of the product profiling in finding a proper process is also confirmed by da Silveira (2005), who confirm a significant negative relationship between profile misfit and domestic market share in a survey of 183 manufacturers in 17 countries.

2.2.4 Capacity

Capacity can be defined in two different ways for manufacturing (Swamidass, 2000): “Capacity is the maximum possible output over a specified period of time. In cases where the output is non-homogeneous, capacity may be measured in terms of the available machine hours”. The first definition measures capacity in terms of products per unit time, which makes it difficult to accurately account for setup times. Typically, the time that capacity is available is reduced with respect to the average proportion of time that is used for setups. Such a standardized approach means that all deviations from “normal” operations lead to erroneous capacity calculations and plans, but since setup times are non-negligible in most manufacturing operations, these must be taken into account
explicitly. This results in a second definition of capacity, using the available (work) time per (calendar) time unit; *e.g.* hours per day.

Capacity as a decision category addresses the timing and amount of capacity acquisitions relative demand; *cf.* Hayes and Wheelwright (1984). Whereas the amount of capacity that can be added is highly dependent upon the type of operations, *e.g.* manual or machine-based, the timing of the capacity addition relative an increase in demand deserves strategic attention. However, the amount of capacity affects the timing, since small or large increases will make it more or less easy to follow the demand pattern. It is for example fairly easy to follow the demand pattern if operations are manual in nature, by adding one more operator will provide a small increase in capacity, whereas in process industries the capacity acquisition is often of extreme strategic importance.

Hayes and Wheelwright (1984) provide two extreme capacity strategies, called lead demand and lag demand. On the one hand a lead demand strategy, or “lead strategy”, implies that capacity is acquired in advance of any demand increase, ensuring that demand can always be fulfilled through internal operations. This implies that there is often an over-capacity. A lag demand strategy, or “lag strategy”, on the other hand implies that capacity is never added unless it can be fully utilized. Using a lag strategy implies that market demand patterns must be carefully monitored and/or that subcontractors or contract manufacturers are needed. As a middle way, Hayes and Wheelwright (1984) include a track demand strategy, or “track strategy”, where capacity should try to closely follow the demand, keeping over- and under-capacities at a minimum. These three generic capacity strategies are illustrated in Figure 5.
The definitions by Hayes and Wheelwright (1984) are extended in Olhager et al. (2001) to account for the fact that capacity strategies are needed also when demand falls. Thus, a lead strategy maintains a cushion of capacity, i.e. there is always a capacity surplus, both when adding and when reducing capacity levels. A lag strategy assures high capacity utilization, a capacity demand surplus, in both increasing and decreasing modes of operation. Finally, a track strategy implies that over- and under-capacities alternate over time.

There are relations between the capacity strategy and the chosen manufacturing environment in terms of process technology, described e.g. by Hayes and Wheelwright (1984), Hill (2000), and Olhager et al. (2001). Lag and level strategies typically apply to line production and continuous processes, and lead and chase strategies to project manufacturing and to some extent to job shops. In line production and continuous processes large steps of capacity are added, and so the capacity acquisition is of vital importance and typically delayed in a way so that utilization is high the instant new capacity is available. In project manufacturing it is quite possible to allocate and add resources to the project as they are needed. Finally, in job shops there is typically one production stage that limits the output of the facility, which is prioritized with respect to capacity utilization and other, complementary, resources may well have high levels of over-capacity.
2.2.5 Facilities

As stated in Table 3, typical decisions to consider for the manufacturing facility are the size, location, and specialisation or focus of the facility. Starting with the decision of size, there is a strong connection to the capacity issue. While industry commonly consider an increased size beneficial from the perspective of economies of scale, Hayes and Wheelwright (1984) also points out that there are diseconomies of scale. As a consequence, there is a range between a smallest and largest size of the facilities which is acceptable, but going too big or too small will result in either diseconomies of, or a lack of economies of scale. What is difficult though is to find this range, and the possibly optimal size found somewhere along this range (Rudberg and Olhager, 2003).

The location decision concerns where to place a set of factories, or how to design a factory network. For international companies there are many possible reasons for positioning facilities in several countries, Ferdows (1997) lists among others the reduction of taxes, better customer service, reduction of currency exchange risks, and lower costs. Ferdows (1997) supplies a chart of strategic roles for foreign factories, as a guide for selecting facility location. Using an optimisation model for the selection of a location is also possible, as described in Arntzen et al. (1995). The focus, or specialisation, decision stems from Skinner’s (1969) call for making manufacturing a part of a company’s competitive edge. Hayes et al. (2005) describe the focus decision as generically one of product or process focus. For value networks with several facilities, however, they add to these another two the possibilities to focus on production volumes and geographic region, making the focus decision a bit more complex.

2.2.6 Vertical integration

From an external perspective, a company is commonly positioned within a supply chain, or value network. Using an internal perspective, the vertical integration refers to those parts of the value network that belong to the company, determined by the policy areas of direction, extent, and balance, as described by Hayes and Wheelwright (1984). An increased vertical integration can thus take two directions, either towards the customers, i.e. downstream, or towards the suppliers, i.e. upstream. Baines et al. (2005) introduce what they call a “competitive space” with a boundary around the
internal manufacturing activities. This boundary does not only cover the length of vertical integration, but also the width. If considering the vertical integration as an internal supply chain, the inclusion of a width corresponds to the terminology of e.g. Stonebreaker and Liao (2004), who limit the supply chain by its breadth and width, and Hayes et al. (2005), discussing horizontal and vertical network structures.

Hayes and Wheelwright (1984) use the term extent to discuss how far the vertical integration stretches, from one single process step to the entire chain in the value network, from raw material to finished good. The balance policy area, finally, includes activities also on the border of the company, by considering dependencies in the value network. To be in full balance there has to be a situation where 100 percent of one of the company’s products goes to one customer, and that this covers all of the customers demand for this product.

2.3 After-sales and service operations management

That service is intangible and heterogeneous are two characteristics that strongly set it apart from goods. When contemplating upon the other service characteristics in Table 1, they can to a large extent be seen as sub-dimensions of the first two. The intangibility on one hand is connected to e.g. the inability to stock services, the real-time execution and the easy of entry thanks to low or no capital entry barriers. On the other hand the heterogeneity is tied to the labour intensiveness; since labour is needed to adapt to each new customer, no two services are identical. When checking a product against the characteristics in Table 1, there are normally some deviations that remove the product from belonging entirely to one the columns. Thus the definition in chapter 2.1, which states that a product may consist of both goods and service properties and characteristics, simultaneously.

2.3.1 Content of service operations management

There are several books available on the topic of service operations management. Among others, the following can be found: Schmenner (1995), Fitzsimmons and Fitzsimmons (1998), Haksever et al. (2000), Johnston and Clark (2001), and Metters et al. (2003). In newer literature on operations management and operations strategy, there is generally also specific attention given to services.
Examples of this are Chase et al. (2001), and Slack et al. (2004). The following sections describe what is seen as unique for service operations compared to traditional manufacturing operations.

The customer is commonly highlighted in service literature, due to the inseparability of the service product and process. Chase (1981), further elaborated in Chase and Tansik (1983) and Chase et al. (2001), developed the customer contact model, focusing on the interface between the customer and the service provider. This model sees a difference between high-contact and low-contact systems, which affects decision areas such as facility location, scheduling, quality control etc. Another way to separate between high and low contact is to use the notions of front-office and back-office or back-room, see e.g. Fitzsimmons and Fitzsimmons (1998) or Metters et al. (2003). An everyday example of this is when ordering a hamburger at a fast food restaurant. In the front-office, you receive your meal, take a seat, and experience the service offering (high contact). The back-office is the procedure of preparing the food, where you as a customer are not involved (thus, low contact). And specifically at fast food restaurants, the back-office operation can be very detailed, with modularised subassemblies and a high efficiency focus.

The intangibility of services disenables stock keeping. It is therefore critical to be able to match capacity with demand, which in turn highlights forecasting as an important issue in service operations (see e.g. Hope and Mühlemann, 1997). Related to this is the potential problem of queue times and bottlenecks in the operation. Queue times are dependent to a large extent on the capacity utilisation, and theoretically queue times goes to infinity as the utilisation approaches 100%. Since a pure service is perishable and cannot be stored or premanufactured, the customer is likely to have a limit for the maximum acceptable queue-time. Unless the queue can be kept at an acceptable level, loss of customers is likely to happen, making queue management a common topic in service management (see e.g. Johnston and Clark, 2001).

Services are labour intensive, as they exist only in the interaction between provider and customer. This leads to a high variability in the actual service, with no two services being identical to each other. Service literature therefore often put a stronger focus on people, rather than on machines and other tangibles. Such focus on human resource management is found in e.g. Haksever et al. (2000).
Areas not found in the service operations management literature are for example inventory management and materials planning. An explanation for this can be found through the characteristics listed in Table 4, which state that a pure service product cannot be stocked. Thus, there is no need for inventory management. Similarly, a pure service product is intangible and therefore has no materials to plan for.

2.3.2 Classifying services and service processes

There are numerous attempts to classify and position services with respect to market and product characteristics on the one hand and on the other hand the service process. In much of this literature, a linkage can be seen to the product-process matrix of Hayes and Wheelwright (1979a, 1979b, 1984); cf. Figure 3. As a start, Chase (1981), further elaborated in Chase and Tansik (1983) and Chase et al. (2001), developed the customer contact model, focusing on the interface between the customer and the service provider. Going forward, Schmenner (1986) uses a two-dimensional typology for services, distinguished on one hand by the degree of labour intensity and on the other hand by the degree of interaction and customisation. Schmenner (1986) uses the same two by two matrix as proposed by Maister and Lovelock (1982), but the latter do not comment on or analyse the effects of the various positions. The Schmenner framework is therefore considered by the service operations literature to be the reference model for this type of positioning. For each of the four service types specified by Schmenner (1986), a set of managerial tasks are proposed. These are tested empirically by Verma (2000), who slightly surprisingly in a sample of 273 firms verifies only four of the twenty challenges originally proposed. The original classification by Schmenner has however been revised (Schmenner, 2004) which addresses that problem. Apart from empirically testing the Schmenner service classification, Verma (2000) provides a literature review of various general service taxonomies found in literature.

2.3.3 Industrial after-sales service

In “After the sale is over…” Levitt (1983) starts by commenting that the relationship between a seller and a buyer is rarely over once the sale is made. Levitt foresaw a future, which now has come, where after-sales activities such as repair, maintenance and retrofitted
enhancements are all part of a system purchased by the customer. Connected to the theory of core competence (Prahalad and Hamel, 1990) customers are interested by the function provided by a product, and not the physical good itself. As a consequence, after-sales service has become less a question of internal maintenance handled by the customer, but instead left to after-sales service providers to handle. The potential value and importance of these after-sales services is highlighted by Knecht et al. (1993), Lele (1997), Wise and Baumgartner (1999), Cohen et al. (2000), Mathieu (2001) and Saccani (2004). Industrial after-sales activities have many names, according to Goffin and New (2001) these include customer support, product support, technical support and service; Nordin (2005a) uses the term product services; and in paper 1 and paper 2 of this thesis the term Industrial services is used. Common attributes for these activities are that they are often critical for the operations at the customer, and also highly profitable for the supplier.

Under the premise that after-sales service is neither a pure good nor a pure service, it should be seen as a product consisting of both goods and service properties and characteristics. Such a view is consistent with Ehinlanwo and Zairi (1996), who include parts, accessories and technical service as traditional after-sales offerings in the car industry. A review of after-sales service definitions is provided by Saccani (2004), looking specifically at durable consumer goods. Turning to industrial after-sales services, this can be said to be a product consisting of tangible goods such as spare parts and consumables, as well as analysis, upgrades, repair work, and similar services, related to the maintenance of an underlying industrial good.

Industrial after-sales services as such cannot be positioned in one clear place in the service classifications presented in section 2.2.3. Of the examples provided in the service literature, two service types are found which are directly related to after-sales service. These are repair shop, typically auto repair (e.g. in Schmenner, 1986, Wemmerlöv, 1990, and Buzacott, 2000) and field engineering service (e.g. in Silvestro et al., 1992). Industrial after-sales services, as used in the title of this thesis, is not yet a commonly used term, which explains the lack of explicit references. Under other names however, various authors have touched upon directly related topics, and the findings of these authors are presented in the following sections.
Levitt (1972) points out that after-sales service (customer service using Levitt’s words) is commonly viewed by manufacturers as something peripheral to landing a sale. He further claims that in order for any kind of services to become more competitive, a manufacturing-type of thinking should be applied to its operations. Later on, Levitt (1983) sets his focus directly on after-sales services when stating that the (new product) sale is only the start of the relationship between the seller and the buyer. Levitt (1983) claim that what used to be the sale of a discrete product or unit will become sales of systems contracts that last over substantial time periods. It is through healthy relationships that long-term profits are secured, and to obtain such relationships the after-sales function of the supplying company is crucial.

The supply of spare parts as an after-sales service is treated by Cohen and Lee (1990), and methods for improved management of spare parts are also discussed by e.g. Cohen et al. (1997), Huiskonen (2001) and Kennedy et al. (2002). Kennedy et al. (2002) provide a comprehensive overview of the research done so far on spare parts, but they also find that with the availability of modern communication tools and with regard to the criticality of many customer installations “more work needs to be done in these areas” (Kennedy et al., 2002, p. 213).

Armistead and Clark (1991) develop a framework for formulating an after-sales support strategy. They highlight the need for manufacturing companies to go further than connecting the manufacturing strategy to product and marketing strategies (as suggested by e.g. Hill, 1995), and to also add an after-sales service strategy to the business strategy (Armistead and Clark, 1991). Also connecting a service strategy to its manufacturing counterpart is McLaughlin et al. (1991), who compare the planning process for the two. Goffin (1999) makes an empirical study on how five different companies have chosen distribution channels for their respective customer support activities. In his conclusions, Goffin (1999) points out that further research regarding customer support is in demand, specifically calling for studies on competitive importance of customer support.

A comprehensive work on the integration of service strategy into manufacturing companies is provided by Mathe and Shapiro (1993). Their book is aimed at an audience of decision-makers and
manufacturing companies’ executives, and highlights the success potential of integrating service strategies, and specifically after-sales services, into the company. Mathe and Shapiro (1993) draw extensively on empirical material from research experience and consultancy activities.

Knecht et al. (1993) find that among industrial companies, after-sales businesses account for 10-20% of revenue, at least so in their four example companies. At the same time, this share of revenue represents 20-40% of profit. Wise and Baumgartner (1999) point to the profitability of after-sales as one reason for companies to expand “downstream”, down the value chain. Alexander et al. (2002) also see the value of industrial service, and turn to factory service centres to find revenue, profit and market information. With long term survival and profitability as a basic target for an industrial company, industrial service must be seen as one important tool in achieving said target. As the after-sales activities are by nature bound do take place during a period of time, and after the initial sale, there is a built in problem on how to valuate the future potential profitability of the after-sales services. This problem is treated by Johansson (2002), considering valuation techniques suited to estimate the present value of future after-sales services.
3 Research design

3.1 Scope

The scope of this research is to analyse how the characteristics of after-sales services affect a company’s manufacturing strategy, which in effect should become an operations strategy not only considering the manufacturing of goods. Staying within this scope, a set of strategic tools is developed, aimed at achieving a more effective operation of industrial after-sales services. This is done by taking established tools from the manufacturing strategy arena, and adapting them to a more service-oriented reality.

One of the two building blocks of this thesis is the characteristic properties of industrial after-sales service operations. These properties are described, starting out from a service perspective, in 2.3. As the second building block the manufacturing strategy framework is used, presented in 2.2.

Substituting manufacturing with the word operations, we should arrive at a framework that encompasses more than the supply of goods. The increased popularity of using operations instead of manufacturing is reflected in this work, as well as in major texts regarding operations, or manufacturing, strategy As this thesis deals with after-sales service products, the term operations strategy is the most appropriate for describing the strategic choices taken by manufacturing companies supplying their customers with both goods and services as described in 2.1. Within the scope is thereby to contribute to the transformation of manufacturing strategy into an operations strategy framework.

In order to keep the scope at a manageable size, only selected parts of the manufacturing strategy framework are included. These are the structural decision categories, as presented in sections 2.2.3 to 2.2.6.

3.2 Objective

Considering the after-sales service as a product, consisting of both good and service characteristics, the objective of this dissertation is to develop conceptual models for an improved long-term management of operations with both new goods and after-sales services. Specifically, the structural decision categories of a
manufacturing strategy, process technology, capacity, facilities, and vertical integration, are adapted to include the demands of after-sales service products.

3.3 Method

This thesis is written within the area of production economics, integrating engineering and economic fields to achieve effective and efficient management of companies. From its engineering heritage this work should be categorized as positivistic; exploring an objective reality that can be predicted and explained with models and logical deduction. The aim is to add to the theory development a new set of tools for industrial as well as academic use.

In the task of achieving this aim, the starting point for this work can be found in manufacturing strategy, although an expansion is made towards the service operations management field. With the industrial use in mind, the aim of this researcher is to present normative findings. Of importance therefore is to propose how companies should be managed, and not descriptions and explanations of how they are managed.

Papers 1, 2, 3 and 6 develop new theoretical tools by using conceptual modelling. While the theoretical tools in papers 1, 2 and 3 are exemplified with short case descriptions, this should not be seen as a use of case study methods. However, in paper 4 explorative methods are used, specifically the case study method, in order to create a better understanding for the problem treated. Seven case companies are used, in line with the guidelines of Eisenhardt (1989). By using several informants and different data sources triangulation is used to check the internal consistency of data (Voss et al., 2002), and cross-case comparisons are made to identify main differences and common behaviours among companies (Yin, 1994). In paper 5 the theory development is based on statistical analysis of a questionnaire submitted to 130 firms operating in the household appliance industry with after-sales operations in Italy. The questionnaire was answered by 45 firms, giving a response rate of 35%.

3.4 Research questions

Given the characteristics of industrial after-sales services as described in chapter 2.3, numerous topics or research questions can
be found and focused upon. In this thesis however, the main research question is how should models be developed so that they will allow industrial after-sales services to be included in the continued development of the operations strategy framework?

The available body of knowledge within manufacturing strategy management is too large to be fully covered within the scope of this thesis. Based on the common division of the manufacturing strategy framework into a set of structural and infrastructural decision categories, the objective of this thesis is focussed on the structural decision categories, i.e. process choice, capacity, facilities, and vertical integration. Thus the four specific research questions treated in this thesis are as follows. (1): How can the process choice decision category of a manufacturing strategy be adapted to suit the needs of an operation where the products produced have both good and service characteristics? (2): How can the capacity decision category of a manufacturing strategy be adapted to suit the needs of an operation where the products produced have both good and service characteristics? (3): How can the facilities decision category of a manufacturing strategy be adapted to suit the needs of an operation where the products produced have both good and service characteristics? And, (4): How can the vertical integration decision category of a manufacturing strategy be adapted to suit the needs of an operation where the products produced have both good and service characteristics?

Based on the research questions and the method used in each paper, it is possible to position the papers and their respective focus as is done in Table 4. It can thus be seen that each paper treats one or two of the structural decision categories, except for paper 6 which is an attempt to answer the main research question, and therefore addresses all of the decision categories.
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<td>Multiple case study</td>
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<td>Facilities</td>
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<td>x</td>
<td>x</td>
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<td>Vertical integration</td>
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### 3.5 Co-author statement

In papers 1 to 5 of this thesis, the work and responsibilities has been distributed between the different authors. The following is to clarify the contributions by the author of this thesis.

Papers 1 and 2 are co-authored with Prof. J. Olhager, and are jointly written by the authors who has commented and edited each others contributions. However, in paper 1 the second chapter is to a large extent the work of Prof. Olhager, whereas the third chapter in most parts work by the author of this thesis. In paper 2, a similar division of work can be seen, with Prof. Olhager writing the major parts of chapter two, and the author of this thesis the most of chapter three.

Paper 3 is, as the previous papers, co-authored with Prof. J. Olhager, although with a lead responsibility by the author of this thesis. The authors have commented and edited each others contributions.

Paper 4 is developed and written jointly by the authors, with Dr. Saccani and the author of this thesis being the initiators and lead writers. The authors have commented and edited each others contributions, with responsibility for the different sections divided according to the following. Sections one and seven are due to Prof. M. Perona, sections two and three are due to the author of this thesis and sections four, five and six are due to Dr. Saccani.

The main author for paper 5 is Dr. Saccani, who has been responsible for the collection of data and the conclusions. The author of this paper has been responsible for data analysis and the
section on configuration of the after-sales service. The authors have commented and edited each others contributions.
4 Summary of papers

This section summarizes the contents and main findings of the papers included as the second part of this thesis. See Table 4 for an overview of each paper’s focus within the thesis, and section 5.1 for a specification of the research contribution.

4.1 Paper 1: Industrial service profiling: Matching service offerings and processes

The first paper elaborates on the possibility of classifying industrial services in a similar fashion as is done in the product-process profile found in manufacturing strategy. This is done through a theoretical classification of various service characteristics into two groups, describing either service offering aspects or service production aspects. The paper shows that industrial service offerings (the product axis in the manufacturing product-process matrix) can be seen as a range: from unique to selective to restrictive to generic services. In a similar way, the service processes range is: professional service to service shop to mass service to service factory. Table 5 shows an example with three products being classified in the industrial service profiling framework.

<table>
<thead>
<tr>
<th>Aspects and markets</th>
<th>Service offering</th>
<th>Service process</th>
<th>Production</th>
<th>Range</th>
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<tr>
<td>Degree of customer/server contact</td>
<td>Unique</td>
<td>Professional service</td>
<td>High</td>
<td>Low/none</td>
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<tr>
<td>Customisation</td>
<td>Selective</td>
<td>Service shop</td>
<td>High</td>
<td>Low</td>
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<td>What do we sell</td>
<td>Restrictive</td>
<td>Mass service</td>
<td>Low</td>
<td>Commodity</td>
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<td>Demand variability</td>
<td>Generic</td>
<td>Service factory</td>
<td>Low</td>
<td>Volume</td>
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<tr>
<td>Profit generator</td>
<td>Profit margin</td>
<td>Degree of customisation</td>
<td>High</td>
<td>Low</td>
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<td>Technology focus</td>
<td>Effectiveness</td>
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<td>Capability of handling variability</td>
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<td>Worker requirements</td>
<td>High-level</td>
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<td>Basic</td>
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Table 5. An example of industrial service profiling (adapted from Paper 1).

○ = product 1
□ = product 2a
✦ = product 2b
The industrial service profile can be used to show misalignments in areas such as: (i) changes over time, (ii) comparison between different offerings, and (iii) comparison between different processes. A straight vertical line in the profile indicates a good match between process and offering, whereas a “dog-leg” means that the process does not fully support the offering. Possible countermeasures to improve the situation are to change either the offering or the process, or even both. Doing nothing to correct the situation is also an option; being aware that the problem exists may also be of help in a troublesome situation. The resulting profiling tool from this paper is meant to be used both for positioning new after-sales service, and also to analyse problems within existing processes and products.

4.2 Paper 2: Linking product-process matrices for manufacturing and service operations

This paper specifically explores the linkage between goods manufacturing and service operations product-process matrices. Product, market demand, and process characteristics can develop differently for after-sales services relative to the manufactured good, making it important to analyse volume, variety, and process issues for both manufacturing and service operations, respectively, in order to create a match between product and process characteristics. Specifically, this paper pays attention to the situation where the industrial good can be serviced in a process similar to that of new goods manufacturing. A framework for process choice in such joint manufacturing and after-sales service operations is developed, and illustrated with an industrial case. The main result is the linking of product-process matrices, as shown in Figure 7.

The linked matrix is derived by evaluating a set of service classification schemes with respect to their after-sales service impact, arriving at a result possible to match with the in operations strategy common Hayes and Wheelwright (1979a) product-process matrix. Whereas the Hayes and Wheelwright matrix has received a large acceptance for manufacturing, there is a much larger discrepancy among the service alternatives, where service classification schemes investigated are those proposed by Chase (1981), Schmenner (1986), Silvestro et al. (1992), Tinnilä and

![Figure 7. Linked product-process matrices.](image)

Depending on characteristics in product, process, demand, and mass customisation, the industrial service can be positioned at any part of the matrix, regardless of the original products’ position. The main usage of the results from this paper lies in the decision of whether to use an integrated or two separated processes for the supply of new goods and after-sales services.

**4.3 Paper 3: Long-term capacity management for integrated manufacturing and service operations**

The purpose of this paper is to contribute to the understanding of strategic capacity decisions for service operations by providing perspectives from manufacturing strategy as well as from sales & operations planning. It is found that chase and level strategies are hitherto defined differently in the service and manufacturing operations literature, and that strategic capacity decisions for service operations would benefit from a distinction between a capacity
strategy (setting the overall capacity level; the options being lead, lag and track) and a planning strategy (managing production relative to demand; a choice between chase and level). In this paper such a framework is developed for the choice of capacity and planning strategies for front-office versus back-office operations.

The aim of this paper is to provide help with strategic capacity decision-making in practice for service industries as well as in integrated manufacturing and service operations environments. It also aids in differentiating service capacity management between front-office and back-office operations. By combining the issue of capacity and planning strategies with the issue of back and front office operations, we find that certain combinations of capacity and planning strategies are linked to either front office or back office operations, as shown in Figure 8.

![Figure 8. Framework for combining capacity and planning strategies for front-office and back-office operations.](image)

### 4.4 Paper 4: Configuration of the after-sales service supply chain - an empirical research

Based on empirical data from seven case studies, the paper analyzes different after-sales supply chain configurations. With after-sales services taking a more central role in the strategy of the company, a need for models describing after-sales activities emerge in industry. The objective of this paper is to provide empirical examples of after-sales supply chain configurations for durable consumer goods, and to profile typical configurations in business practice. Cases sampled cover after-sales activities in white goods, heating appliances and consumer electronics. Analyzing technical assistance, customer care and spare parts distribution, different after-sales supply chain
configurations emerge, related to the different levels of decoupling, centralization and outsourcing of activities, as described in table 6. According to that, three different profiles are identified and described: efficiency and control oriented firms, service oriented firms and cost reduction oriented firms.

Table 6. Summary of findings in paper 4

<table>
<thead>
<tr>
<th>Decoupling of activities</th>
<th>Technical assistance network</th>
<th>Customer care</th>
<th>Spare parts distribution network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Different number of tiers (from one to three). Decoupling points are generally not clearly defined in the cases</td>
<td>Call centres and Internet applications are the on-line channels. Physical contact with the assistance network is also important. There is a lack of clearly defined decoupling points</td>
<td>One or two-level distribution networks</td>
<td></td>
</tr>
<tr>
<td>Highly decentralized. Only one clear exception exists, with a centralized in-house repair centre in one of the case companies.</td>
<td>On-line channels are centralized and controlled by the manufacturers. Physical contact is decentralized, there is a need for geographical closeness</td>
<td>Decentralized in most cases.</td>
<td></td>
</tr>
<tr>
<td>Mostly outsourced, but some control is kept: Franchising as well as mono-brand agreements are used.</td>
<td>Call centres are both insourced and outsourced.</td>
<td>All transports are outsourced to third party logistics companies.</td>
<td></td>
</tr>
</tbody>
</table>

4.5 Paper 5: The after-sales service, aligning supply chain configuration with strategy - evidence from the household appliance industry.

This paper describes a newly developed taxonomy of after-sales strategic profiles, and investigates the related after-sales configurations with respect to facilities and how they are vertically positioned within the companies. The taxonomy is applied to a sample of 45 firms active in the household appliance industry (white goods, small appliances, and heating and air conditioning) in the Italian market. The after-sales strategy pursued by groups within the sample is pointed out, and a set of configuration choices is evaluated for each group. Collected data makes it possible to stress cases of alignment and misalignment between strategy and
configuration, and to point out industry-specific features. Three strategic groups of after-sales strategies are found: (i) Product focus, focusing on the underlying physical product, (ii) Business generator, looking for direct revenue and profit from after-sales services, and (iii) Brand fostering, aiming for long term customer loyalty. The analysis of the physical and organisational choices concerning after-sales shows generally a good fit with strategies, although exceptions exist, especially in the Brand fostering group. The main findings are summarised in Table 7.

| Table 7. Summarized scheme of main empirical findings of the study. |
|---|---|---|
| Strategy profile | Organisational choices |
| | After sales service organisation | Distribution service organisation | Performance monitoring |
| **Product focus** | Internal department reporting to CEO | Mainly 1 or 2 levels distribution networks | Low percentage of profitability evaluation |
| | Organisation by geographical area | | |
| | Extremely variable no. of multi-brand, third party service units | | |
| **Business generator** | High percentage of independent BU | 1 level distribution networks. By exception 2 or even 3 levels | High percentage of profit centres |
| | Organisation by product line | | High percentage of profitability evaluation, on the short term |
| | High no. of third parties service units; high percentage of mono-brand | | High percentage of cost and revenue internal and external evaluation |
| **Brand fostering** | Internal department reporting to internal function, mainly marketing & sales. Organisation by geographical area | Mainly 2 or 1 levels distribution networks | Low percentage of profit centres |
| | Lower no. of multibrand, third party service units | | Low percentage of cost internal evaluation |
| | | | Low percentage of quality internal evaluation |
4.6 Paper 6: Adapting manufacturing strategy to the increased service content of products

By adding results from research on service operations to the manufacturing strategy framework, the transformation towards a generic operations strategy framework is well on the way. The objective of this paper is to investigate how the manufacturing strategy framework needs to be changed in order to better cover the simultaneous good and service content of products in general and after-sales services in particular. Specific focus is placed on the effects on the structural decision categories of a manufacturing strategy.

In order to complete the transformation from manufacturing to operations strategy, more service characteristics must be adapted, as well as the concept of products as a goods and service combination. Using after-sales services as an example of such combined goods/service products, Table 8 summarises how the structural decisions categories found in an operations strategy could be adapted to be more suited to handle the service aspects of products and operations.

Table 8. After-sales service effects on the structural decision categories.

<table>
<thead>
<tr>
<th>Decision categories</th>
<th>Manufacturing policy areas</th>
<th>After-sales service perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process technology</td>
<td>Process choice, technology, integration</td>
<td>Normative model for process choice similar to manufacturing’s, but with more characteristics to consider.</td>
</tr>
<tr>
<td>Capacity</td>
<td>Amount, timing, increment size</td>
<td>Strongly determined by staffing, and directly connected to quality. Division into front and back office capacity possible, similar to customer order decoupling in manufacturing.</td>
</tr>
<tr>
<td>Facilities</td>
<td>Size, location, specialisation and focus</td>
<td>Location, proximity to customer is crucial, especially for front office. Centralisation for increased efficiency taking place.</td>
</tr>
<tr>
<td>Vertical integration</td>
<td>Direction, extent, balance</td>
<td>Direction suggested by profitability of downstream services. “Virtual” integration through various agreements and contracts taking place.</td>
</tr>
</tbody>
</table>
5 Conclusion

5.1 Research contribution

As an overall thesis contribution, a focus is set on the need to adapt operations strategy to an increasing level of service content in products. This is done by introducing theoretical tools, which can aid in the strategic work with the structural decision categories, and which are adapted to the demands raised by the after-sales operations in companies. Turning to the four specific research questions in 3.4, they are as follows:

Research question (1): How can the process choice decision category of a manufacturing strategy be adapted to suit the needs of an operation where the products produced have both good and service characteristics?

In Paper 1 it is found that the specific service characteristics of industrial after-sales services leads to a larger total set of characteristics to consider when deciding upon or evaluating a production process, compared to traditional goods-focused process choice. Paper 2 conclude that the choice of process depends upon volume relations between the industrial after-sales service products and the underlying goods.

An after-sales service adapted product profiling tool is introduced in Paper 1, and exemplified with an industrial example. Paper 2 focuses on the question if the after-sales service production process should be integrated with the new product process or not, and by investigating various product-process matrices a decision tool is developed that aids decision makers facing an opportunity to merge (or split) the processes.

Research question (2): How can the capacity decision category of a manufacturing strategy be adapted to suit the needs of an operation where the products produced have both good and service characteristics?

Paper 3 shows that different capacity strategies are appropriate for front office and back office service operations, respectively. This difference is similar to the differentiation of strategies before and after a customer order decoupling point in the manufacturing case. It is also beneficial for service operations to make a distinction between capacity strategy (long term) and planning strategy (medium-to-long term). Also in paper 3, lead-lag- and level-chase-concepts are analysed to give a more detailed capacity management
framework for services in general, and specifically for after-sales services.

Research question (3): How can the facilities decision category of a manufacturing strategy be adapted to suit the needs of an operation where the products produced have both good and service characteristics?

And,

Research question (4): How can the vertical integration decision category of a manufacturing strategy be adapted to suit the needs of an operation where the products produced have both good and service characteristics?

Papers 4 and 5 both investigate empirically (through cases and a survey) facilities and vertical integration of after-sales service activities. Supply chains and configurations of after-sales units are mapped, in order to find the specific characteristics of these activities. It is found that the awareness of after-sales potential value has not been realised among all suppliers, with some still having a “necessary evil” approach to after-sales. Some of the case companies in paper 4 have however come quite a long way in their work with their after-sales business, and have given it an internal strategic importance. It can thus be seen that awareness of the importance of services in industry is increasing, at least for after-sales services.

The main research question is how should models be developed so that they will allow industrial after-sales services to be included in the continued development of the operations strategy framework?

Paper 6 attempts to provide a larger perspective, covering all four structural decision categories. By doing this a “true” operations strategy perspective is taken, meaning that the structural decision categories are updated with respect to the impact of services in general and after-sales services in particular. Paper 6 thereby contributes to the operations strategy research by summarising available research, as well as setting directions for continued research, on the structural decision categories.

5.2 Future research

As a natural continuation of the work presented in this thesis, the infrastructural decision categories would benefit from an analysis of the impact of service content in supplied products. Such a path for future research would result in a more complete view of the content of an operations strategy, and thus be able to better suggest how
companies should strategically manage their operations. Apart from the content of an operations strategy, the process of the same is a topic where the service characteristics in products have not been accounted for. By investigating the process of operations strategy in companies actively working with the integration of after-sales services into their production facilities, it should be possible to begin providing normative guidelines for how this process should be carried out.

The tools proposed in this thesis could also be worked on further. They are now adapted for mainly one “type” of product, the industrial after-sales service. There are of course many more products in the good-to-service range, and one course to take with the continued work is to attempt to create a generalisation of the proposed strategic models to suite a larger set of products. With an intent of improving and extending the operations strategy framework into a more complete theoretical body, such generic normative models would be a necessary step to take. However, before attempting to generalise the models in this dissertation, it would also be valuable to verify the models on a broader scale than what has been done in this thesis. Going all the way back to the original reason that this research was initiated, a very appealing way forward would be to bring the models back into industry, and see how their applicability is in real life. Two realistic ways to do this would be qualitatively through case studies or quantitatively through a survey of e.g. industrial practices. From an industrial perspective, having case descriptions of good implementations of an after-sales service adapted operations strategy is of interest. Working with deeper case studies would allow verification and improvement of the models proposed here, as would probably a statistical study based on e.g. a survey of industrial experience and usage of the proposed models. Considering though how relatively new the operations strategy framework still is, there may very well be quite varying interpretations in industry what is implied with the various concepts and models in the framework. Thus from a methodical view, going forward with deep case studies seems to be the most logical path, and to sum, the preferred path for future research is to verify and improve the models proposed by performing in-depth industrial case studies.
5.3 Reflections

This thesis is concentrated on the structural decision categories found in a manufacturing strategy, and on how to adapt them to an increased service share in products supplied. In retrospect, it would have been no problem to find enough research questions on one single decision category to provide material for a complete thesis. Thinking on how to find a good topic for new or future doctoral theses, it is certainly relevant to bear in mind the importance of starting out the research process with a truly narrow focus. Although based on the experience of these past years, it is not quite as easy as it is important to keep that focus throughout the process.

Reading and studying various research findings and ideas not directly applicable to this thesis has been one of the big benefits of being a doctoral student. However, not only the reading and studying but rather the discussions in the academic environment have strongly contributed to a personal development during the past years. To have time available for both contemplation and exchange of ideas is not something normally found in the daily “rush” of industrial operations, and while it may probably not be so visible in the words of this thesis, the awareness and perspectives gained from this is on a personal level very valuable. Having had this time and opportunity, in a world that seems to be spinning faster and faster, is indeed a luxury.
References


