LUT School of Business and Management

Master's Degree Programme in Supply Management

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# IDENTIFYING AND EVALUATING PRODUCTIVITY IMPROVEMENT OPPORTUNITIES IN SERVICES: CASE HARDWARE REPAIR AND MAINTENANCE SERVICE

Master's Thesis 2019

Examiners: Professor Jukka Hallikas

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# TIIVISTELMÄ

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|---|---|
| **Tekijä:** | Ronkainen, Jani Tapio |
| **Tutkielman nimi:** | Identifying and Evaluating Productivity Improvement Opportunities in Services: Case Hardware Repair and Maintenance Service |
| **Tiedekunta:** | LUT School of Business and Management |
| **Pääaine:** | Supply Management |
| **Vuosi:** | 2019 |
| **Pro Gradu -tutkielma:** | 73 sivua, 26 kuvaa, 2 taulukkoa, 3 liitettä |
| **Tarkastajat:** | Professori Jukka Hallikas |
| | Professori Mikko Pynnönen |
| **Avainsanat**: | Palvelun tuottavuus, tuottavuuden parantaminen, failure modes and effects analysis, analytic hierarchy process |
| **Keywords:** | Service productivity, productivity improvement, failure modes and effects analysis, analytic hierarchy process |

Teollisuudessa tuottavuuden käsite on hyvin ymmärretty ja sitä tyypillisesti johdetaan aktiivisesti teollisuusyrityksissä. Tämän tutkimuksen tavoitteena oli ensin selvittää kirjallisuuskatsauksen avulla, mitä tuottavuuden käsite merkitsee palveluiden tapauksessa. Tämän jälkeen kehitettiin järjestelmällinen menetelmä palvelun tuottavuuden parantamismahdollisuuksien tunnistamiseksi ja arvioimiseksi.

Tutkimuksen empiirisessä osiossa toteutettiin tapaustutkimus, jossa kehitettyä menetelmää sovellettiin suomalaisen turvallisuusalalla toimivan yrityksen korjaushuoltopalveluun. Tutkimuksessa hyödynnettiin sekä laadullista että kvantitatiivista dataa, jota kerättiin kahdesta aivoriihi- ja tiimityöskentelytilaisuudesta joihin osallistui viisi case-yrityksen työntekijää tutkittavan palvelun eri osa-alueilta. Menetelmän avulla kyettiin tunnistamaan tuottavuuden kehitysmahdollisuuksia ja priorisoimaan ne järjestelmällisen arvioinnin pohjalta.

# ABSTRACT

| | |
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| **Author:** | Ronkainen, Jani Tapio |
| **Title:** | Identifying and Evaluating Productivity Improvement Opportunities in Services: Case Hardware Repair and Maintenance Service |
| **Faculty:** | LUT School of Business and Management |
| **Master's programme:** | Supply Management |
| **Year:** | 2019 |
| **Master's thesis:** | 73 pages, 26 figures, 2 tables, 3 appendices |
| **Examiners:** | Professor Jukka Hallikas |
| | Professor Mikko Pynnönen |
| **Keywords:** | Service productivity, productivity improvement, failure modes and effects analysis, analytic hierarchy process |

Productivity is a well-established concept in manufacturing where productivity is typically measured and managed to a great extent. The aim of this paper was to first examine the specificities of the productivity concept when the term is applied to services. Once the concept of service productivity was elaborated through a literature review, a systematic method for identifying and evaluating service productivity improvement opportunities was developed and empirically tested.

The empirical section of the paper comprised a case study where the developed service productivity improvement approach was applied to an existing service of a company operating in the Finnish security industry. The empirical research combined both qualitative and quantitative methods, and the methodology was characteristic of both a case study and action research. Data was collected from two brainstorming- and teamwork sessions with five case company employees where the developed method was performed by the company team. The results of the empirical study suggest that the developed method provides a viable approach for identifying productivity improvement opportunities in existing services, and then prioritizing the identified opportunities based on systematic evaluation.

ACKNOWLEDGEMENTS

I would like to thank my thesis supervisor Prof. Jukka Hallikas for the support and guidance provided throughout the process of writing this thesis. I would also like to express my gratitude to Kaarlo Kankkunen for granting the time, resources and support required to complete this study on schedule. The case company team involved in the empirical study of this thesis was of great assistance and I would like to thank them for their time and participation.

In addition, I want to express my heartfelt gratitude to my wife Anna for her support and perseverance through the busy and challenging times during the writing process. Your help was invaluable and you made the writing process feel much easier.

Jani Ronkainen

Helsinki 21.5.2019

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| **AHP** | Analytic hierarchy process |
| **CR** | Consistency ratio |
| **ERP** | Enterprise resource planning |
| **FMEA** | Failure modes and effects analysis |
| **MCDM** | Multiple-criteria decision-making |
| **PDA** | Personal digital assistant |
| **RPN** | Risk priority number |
| **SLA** | Service level agreement |
| **SMS** | Short message service |

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# 1. INTRODUCTION

Productivity is a well-established concept in the domain of manufacturing to manage production efficiency (Grönroos and Ojasalo, 2004). However, the characteristics of service and service consumption can make traditional productivity improvement methods and measures incompatible to the extent that apparent improvements in production efficiency result in reduced profitability of the service (Grönroos and Ojasalo, 2004; Rust and Huang, 2012). Hence, service company managers should first understand the dynamics of service productivity before implementing productivity actions to avoid damaging service profitability.

This paper first examines the specificities of the productivity concept when it is applied to services. Then, a practical approach to identify and evaluate productivity improvement opportunities in an existing service is developed and empirically tested. The developed method combines the failure modes and effects analysis with the analytic hierarchy process. The method is then empirically tested by applying it to the hardware repair and maintenance service process of a Finnish security installation company. This paper consists of six chapters. In this first chapter, the background of the study, the research problem, key concepts and framework of the study are presented.

## *1.1 Background*

The subject of productivity has been studied for almost a century and improving productivity has been the focus of production companies as a key method to increase their profitability. In a traditional manufacturing setting, measuring and managing productivity is often relatively straightforward, as the inputs and outputs of an unambiguous production process are usually identified without difficulty. Increasing the ratio of outputs to inputs will yield productivity improvements and typically results in increased profitability.

However, as the more economically developed countries have seen the shift from basic manufacturing towards a dominant service sector, the concept of productivity has required a thorough revision from academics. It was soon identified that directly transferring the manufacturing productivity concepts into services can prove cumbersome if not impossible and, at worst, lead to decreased profitability. Hence, service productivity has necessitated its own line of research and discussion that clearly differentiates itself from the field of manufacturing productivity.

Major topics in previous studies on service productivity have focused on issues related to service productivity measurement (Mark, 1986; Gupta, 1995; Nachum, 1999) and the importance of considering the customer perceived quality aspect in the pursuit of service productivity improvements (Filiatrault, Harvey and Chebat,1996; Grönroos and Ojasalo, 2004; Calabrese, 2012). While the majority of previous studies have mainly discussed service productivity on a holistic level, this study aims to first aggregate the most pertinent findings from previous literature and then develop a method for service productivity improvement. The method for identifying and evaluating productivity improvement opportunities developed in this thesis provides a novel approach of combining the chosen decision-making support tools with service productivity theory.

## *1.2 Research problem, objectives and delimitations*

The main research problem of the thesis is as follows:

- How the productivity of a service can be improved?

In order to approach this question, it is essential to first establish what productivity means in the context of services. The assumption is that the concept of productivity established in manufacturing is not directly applicable to the service context. The first sub-question is therefore:

- What is service productivity?

Once the meaning of service productivity is established, the modes of evaluating and improving service productivity are discussed and empirically examined. The second sub-questions is therefore:

- How can service productivity improvement opportunities be identified and evaluated?

This study hereby focuses first on establishing a meaningful understanding of what the concept of productivity comprises in the case of services, and then on the identification- and evaluation methods of service productivity improvement opportunities which are empirically tested later in this study. The objective is to combine the service productivity concept with the identification- and evaluation methods such that the methods are able to focus specifically on productivity aspects of a service.

The actual implementation and measurement of the identified and evaluated productivity improvement opportunities are not observed and reported due to time and space constraints. The theory and issues related to service productivity measurement are also not discussed in detail. The empirical section is limited to a single service of one company, thus any wider theoretical generalizations will not be pursued. The effects on profitability are not considered in this study.

## 1.3 Definition and key concepts

### 1.3.1 Service

Service is a process or an activity performed for the benefit of the customer. Services are typically characterized by their intangibility, heterogeneity, perishability and inseparability of production and consumption. These properties differentiate services from physical goods and induce challenges in their quantification. The difficulty of quantifying service or its elements is one of the major challenges for productivity measurement, as most productivity measures originate from manufacturing, where both inputs and outputs are easily quantifiable. The customer's active role in the production process of a service is another major factor that differentiates service from traditional goods and affects the way productivity is conceptualized.

### 1.3.2 Productivity

Productivity is typically defined as the efficiency of transforming input resources into economic results (Grönroos and Ojasalo, 2004) or simply the ratio of actual output to input over a period of time (Johnston and Jones, 2004). Thus, productivity can be improved in three ways; by producing the same output with reduced input resources, by producing more output with the same amount of input resources, or by simultaneously reducing the amount of input and increasing the amount of output. Productivity combines the concepts of effectiveness and efficiency.

$$Productivity = \frac{Economic\ output}{Input\ resources}$$

### 1.3.3 Effectiveness

Effectiveness is here defined as the ability to successfully produce a desired or expected result, such as fulfilling customer needs to a given standard.

### 1.3.4 Efficiency

Efficiency is often considered synonymous to productivity. However, efficiency is focused on the input side of the productivity equation, in that it means the ability to produce a desired result without wasting resources, that is, with as little input as possible.

### 1.3.5 Process

A process in the context of the thesis is a set of activities that produce a specific service for customers by transforming input resources into valuable outputs.

### 1.3.6 Service quality

Service quality denotes the relationship between a customer's expectation of service and the perceived performance of the service. If the service exceeds customer expectations, service quality is considered high. Service quality can provide the basis for enhanced loyalty, retention and improved business performance, as offering a superior service which the competition cannot match provides customers with a reason for not switching suppliers (Ennew and Binks, 1996).

## 1.4 Framework of the thesis

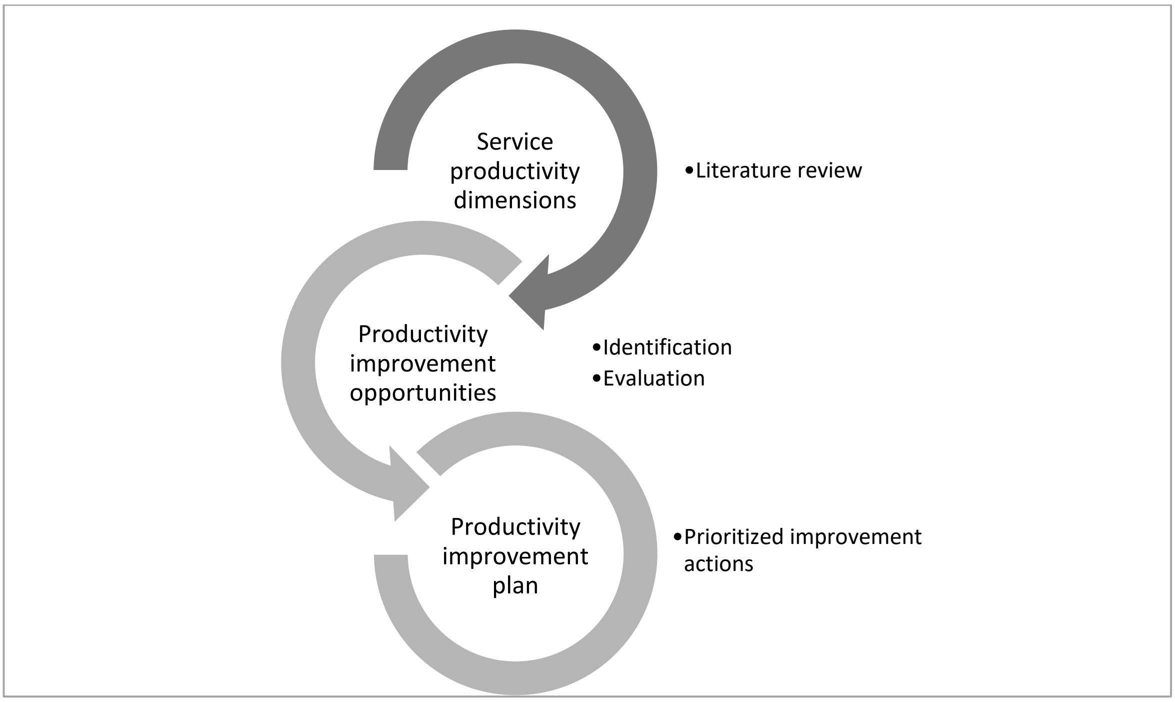


*Figure 1 - Framework of the thesis*

The conceptual framework consists of three stages. First, the specificities of service productivity are clarified to understand the influential factors and their interrelationships. Once they are known, the methods for identifying and evaluating productivity improvement opportunities are examined. Then, the concept of service productivity and the discussed methods are combined into a practical productivity improvement approach that is empirically tested by applying the approach to a case service. The intended output of the approach is a systematically derived productivity improvement plan for a service.

### *1.5 Structure of the thesis*

This paper is divided into two parts, a literature review and an empirical case study, and consists of six chapters. Chapter two discusses the concept of productivity in services through a literature review. In chapter three, methods for identifying and evaluating service productivity improvement opportunities are discussed. Then, the methodology of the empirical study is explained in chapter four. The empirical case study is reported in chapter five. Finally, conclusions are drawn in chapter six.

# 2. PRODUCTIVITY IN SERVICES

Productivity at the company level is essential to profitability and survival, especially in mature and highly competitive industries where market growth and increased sales volumes offer less potential for increased profits (Ojasalo, 1999, 2). The traditional concept of productivity originates from the domain of manufacturing, where input resources, such as raw materials, energy, capital and labor, are combined and transformed in a production process into valuable outputs, typically physical goods which can be further distributed and sold to customers or stored for later consumption. Productivity improvements can be achieved by coping with less input resources, by producing more output with the same resources or simultaneously reducing inputs and increasing outputs. In other words, productivity of a process equals the ratio between outputs produced and inputs required to produce those outputs.

However, this traditional approach to productivity improvement holds some strong assumptions that conflict with the characteristics of services and service productivity. This chapter focuses on examining how the characteristics of services affect the way productivity should be perceived, what factors should be considered when service productivity is discussed and why productivity improvements in services require a distinct approach from the traditional view.

The remainder of this chapter is structured as follows: first, a general model of service productivity is discussed based on previous studies on service productivity on a conceptual level. Second, the importance of service quality for service productivity is discussed in more detail. Third, the trade-off effects between productivity and quality in services are discussed. Fourth, human resources and their effects on service productivity are discussed. Finally, the subject of improving and optimizing service productivity is discussed.

## *2.1 From manufacturing to service provision*

In the domain of manufacturing, productivity is a relatively well-established and understood concept. Productivity is traditionally defined by the relation between output and input (Bian and Zhang, 2007), which denotes the efficiency of a closed production process, that is, how efficiently the input resources are transformed into outputs. The inputs typically comprise labor, capital and other real resources which are quantifiable and measurable (Mark, 1986; Gupta, 1995). The outputs, correspondingly, tend to be tangible products and product quality is defined as conformance to standards which are set and managed internally by the firm through quality control (Yalley and Sekhon, 2014). Hence, given these circumstances, measuring and managing productivity is essentially a matter of defining the relevant inputs and outputs, then focusing on removing waste and reducing costs (Grönroos and Ojasalo, 2015).

Following this logic, the outputs and inputs are homogenous and standardized, and output quality can be considered constant (Ojasalo, 1999, 57). This permits changes in the input structure without affecting the utility for end customers. A furniture manufacturing company might relocate its production facilities to a country with lower labor costs, thus changing its input structure, while keeping the quality of its products constant if the employees are able to conform to given quality standards and operate the production machinery. Customers only see the quality of the end product, not the process in which the products are made. Thus, productivity is traditionally defined and measured in a closed system, where the transformation process of inputs to outputs is isolated from any external influences (Ojasalo, 1999, 57). This conforms to the profit logic of traditional manufacturing where sales and marketing make promises, and revenues are dependent on keeping those promises through product quality management (Grönroos and Ojasalo, 2015). Production and consumption are thus considered separate processes (Ojasalo, 1999, 59). This enables producing tangible outputs in advance at a constant rate, as the outputs can be warehoused for later consumption.

In sum, the traditional concept of productivity is predominantly built around a tangible product and viewed mainly from the producer's perspective. Service production, however, diverges significantly from the traditional product-centricity, largely due to the inherent characteristics of services and their impact on the assumptions included in the traditional view to productivity. Ojasalo (1999, 58) suggests that five characteristics of services, namely intangibility, heterogeneity, simultaneity of production and consumption, customer participation and perishability, make the traditional concept of productivity unsuitable for most services (see Figure 2).

| **Assumptions included in the traditional concept of productivity** | **Characteristics of services and service production** |
| --- | --- |
| • Outputs and inputs are tangible, easily defined and measured | • Outputs and inputs are more or less intangible, thus difficult to quantify and measure |
| • Outputs and inputs are homogenous, output quality is constant | • Outputs and inputs are heterogeneous, customized, output quality is variable |
| • Production and consumption are separate (closed system) | • Production and consumption are partly simultaneous<br>• Output includes both the process and the outcome |
| • Customers do not participate in the production (closed system) | • Customers participate in the production process |
| • Constant amount of outputs can be produced and inventoried (closed system) | • Output quantity is dependent on demand because services cannot be inventoried |

*Figure 2 - Differences between service characteristics and the traditional concept of productivity, adapted from Ojasalo (1999, 59)*

The intangible nature of services complicates the assessment of both input quantity and output quality. As stated by Grönroos and Ojasalo (2004), clearly defining one unit of service is seldom possible, which leads to problems when trying to apply traditional productivity measures into service processes. Inputs in service production can comprise measurable factors, such as hours worked by employees or calls per day, but also factors that are difficult to quantify, such as information and skills required to produce the service more efficiently.

Further, in services, customers often participate in the production process and service delivery to some extent, thus providing some input to the productivity equation which can impact productivity both positively and negatively (Ojasalo, 2003). Efficiency, then, is not solely dependent on the service provider's actions (Johnston and Jones, 2004). Moreover, since outputs are typically difficult to quantify and qualify due to the intangible nature of services, obtaining meaningful information from traditional output-to-input ratios becomes troublesome in service production.

Traditional productivity models thus consider productivity in a closed system, that is, they assume that production and consumption are separate processes and customers do not participate in the production process (Grönroos and Ojasalo, 2004). In a closed system, inventory separates internal production from the external environment, serving as a buffer between production and sales. However, as services are often perishable and thus impossible to store, service productivity is directly influenced by demand and highly dependent on capacity flexibility and the ability to anticipate demand fluctuations (Ojasalo, 1999, 64). Services are typically more or less produced and consumed simultaneously, which implies that customers have an active role in service production.

The role of customers in service production has further implications to service productivity. Customers may offer both tangible and intangible input resources and produce parts of a service themselves. This introduces uncertainty to the input side of the productivity concept, as demands, expectations and behaviors of customers can vary significantly, which affects the producer's ability to standardize production. The output side is also affected, as the customers' willingness and ability to provide quality inputs and to participate in the service production process is likely to impact both the quantity and the perceived quality of the provided service. Thus, in service production, customers can have two distinct roles, namely resource providers and co-producers. (Ojasalo, 2003)

The fact that most services are produced and consumed simultaneously also has an impact on how output quality should be assessed in service productivity. In contrast to manufacturing where firms offer pre-produced products to customers who only experience the quality of the end product, in service production customers experience the quality of both the delivery process and the resulting outcome. Grönroos (1998), who studied service productivity from a services marketing perspective, states that while the consumption of physical goods can be considered outcome consumption, the consumption of services can be characterized as process consumption. Grönroos (1998) emphasizes the process nature of services as the most important service characteristic, which means that service companies offer processes to their customers instead of physical goods. Most services can be considered "performances" that are produced and consumed simultaneously through interactions between producers and consumers (Parasuraman, 2010). Hence, as customers participate in the production process and interact with the company's resources, the process can be characterized as an open process (Grönroos, 1998).

## *2.2 Service productivity models*

Evidently, the characteristics of services, the process nature of service provision and the active role of customers in the service production and delivery processes affect the way productivity should be understood and evaluated in services. Academics have studied the field of service productivity for a few decades as the role of service industries and services in general began dominating developed economies, and as a result some productivity models have been developed. Next, two general service productivity models will be discussed.

One of the first productivity models specifically for services was developed by Ojasalo (1999, 71) and further developed by Grönroos and Ojasalo (2004). According to the model by Grönroos and Ojasalo (2004) illustrated in Figure 3, service productivity is a function of three efficiencies, namely *internal efficiency*, *external efficiency* and *capacity efficiency*. Internal efficiency denotes the efficient use of both provider and customer inputs and the provider's ability to educate and guide its customers to give high quality inputs to support the production process. Since customers participate in the production and delivery of services and provide some of their resources as input, it is seen essential that providers realize the need to support and develop their customers' ability to provide inputs that are of high quality, as it has a direct impact on productivity. This can be promoted through long-term relationships, as the customer and the service provider will be better acquainted with each other and the requirements of the service process. By knowing the customer better, the service provider is also able to tailor the service to better meet the customer's expectations. Thus, relationship continuity promotes mutual learning which enhances service productivity (Grönroos and Ojasalo, 2015). Internal efficiency also comprises the cost efficiency factor analogous to the traditional productivity concept.

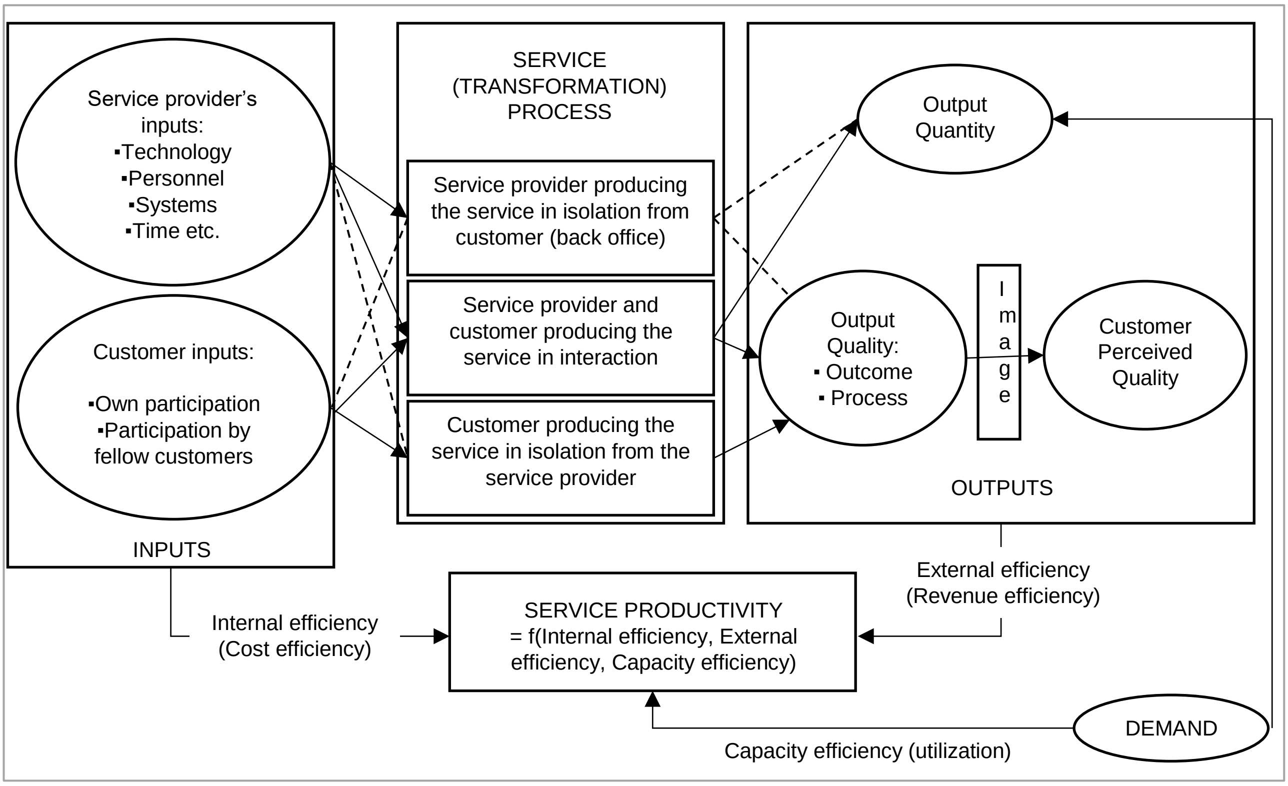


*Figure 3 - A service productivity model by Grönroos and Ojasalo (2004)*

The model then divides the service production process into three separate processes which are directly or indirectly affected by provider and customer inputs. Typically producing a service can comprise different functions; back-office tasks can be produced by the service provider in isolation from the customer, some tasks are performed in interaction between the provider and the customer, and some tasks can be performed by the customer in isolation from the provider using the provider's infrastructure.

Back-office tasks are directly affected by the provider's inputs and indirectly by the customer's inputs, for example by providing information or material to be processed in the back office (Grönroos and Ojasalo, 2004). As this area is invisible to customers, it is closest to the traditional concept of productivity because the characteristics of service do not necessarily play a significant role, that is, production and consumption are separated, customers do not participate and sometimes stocks can be kept (Ojasalo, 1999, 73). By contrast, the characteristics of services are most evident in tasks that are performed in interaction between the provider and customer. These tasks are directly affected by both the provider's and the customer's inputs, as both are present in the encounter and provide their resources to the process. Finally, tasks that are performed by the customer in isolation from the provider are directly influenced by the customer's inputs and indirectly by the provider's inputs. For example, airline passengers can do a self-service check-in by themselves, but it is indirectly affected by the airline by providing the required infrastructure to perform the self-service check-in.

The resulting output is then divided into quantity and quality. Since services typically cannot be stored for future consumption and they are produced and consumed simultaneously, output quantity or volume is largely dependent on demand. Thus, service providers face the challenge of optimizing their production capacity to meet more or less fluctuating demand. *Capacity efficiency* denotes the balance between capacity and demand. If demand exceeds capacity or vice versa, capacity efficiency is not optimal and productivity is adversely affected (Grönroos and Ojasalo, 2004). If demand exceeds capacity, typical consequences may include longer waiting times for customers and reduced service quality when the service staff is required to constantly work under full load. On the other hand, if capacity exceeds demand, the service staff is partially unemployed and not generating revenue while their costs keep accumulating. On both occasions, capacity efficiency is sub-optimal and service productivity is impaired.

The output quality in services is more complex than in traditional products. Because service production is an open process, that is, the customer participates in the production and delivery of the service, the quality of the process itself must be considered in addition to the quality of the outcome of that process. As stated by Grönroos and Ojasalo (2004), the quality of service output is partly manifested in the process as *interaction-induced quality*, and partly in the outcome of the process as *outcome-induced quality*. The resulting quality perceived by the customer denotes the *external efficiency* of the service; higher perceived service quality equals higher external efficiency which results in better service productivity. It is important to realize that in services, it is often not enough to offer a superior end product if the supporting production- and delivery processes are inefficient and cause inconvenience to the customers. As stated by Grönroos (1998), service consumption is often considered process consumption instead of outcome consumption, thus solely focusing on the quality of the outcome will likely result in weak overall service quality and frustrated customers.

Further, as the customers experience the quality of the process and interact with the provider's resources, changes made to the provider's input structure will likely impact the customer perceived service quality and thus external efficiency. This diverges from the traditional view to productivity where output quality is considered constant, which promotes seeking productivity gains through cost cutting and automation. It is therefore important to notice that managing service productivity requires balancing internal efficiency and external efficiency through the use of the service provider's input resources (Grönroos and Ojasalo, 2004). For example, outsourcing customer service from abroad might yield noticeable short-term cost benefits, but the impact to customer perceived service quality might decline so much that long-term productivity is impaired as customers eventually switch to suppliers offering higher quality service.

In sum, the service productivity model by Ojasalo (1999, 71) separates itself from the traditional view to productivity by recognizing the characteristics of services and how they affect the consumption of services compared to traditional products. Instead of focusing on the ratio between outputs and inputs, it is more meaningful to focus on internal efficiency, external efficiency and capacity utilization when service productivity improvements are pursued (Ojasalo, 1999, 160).

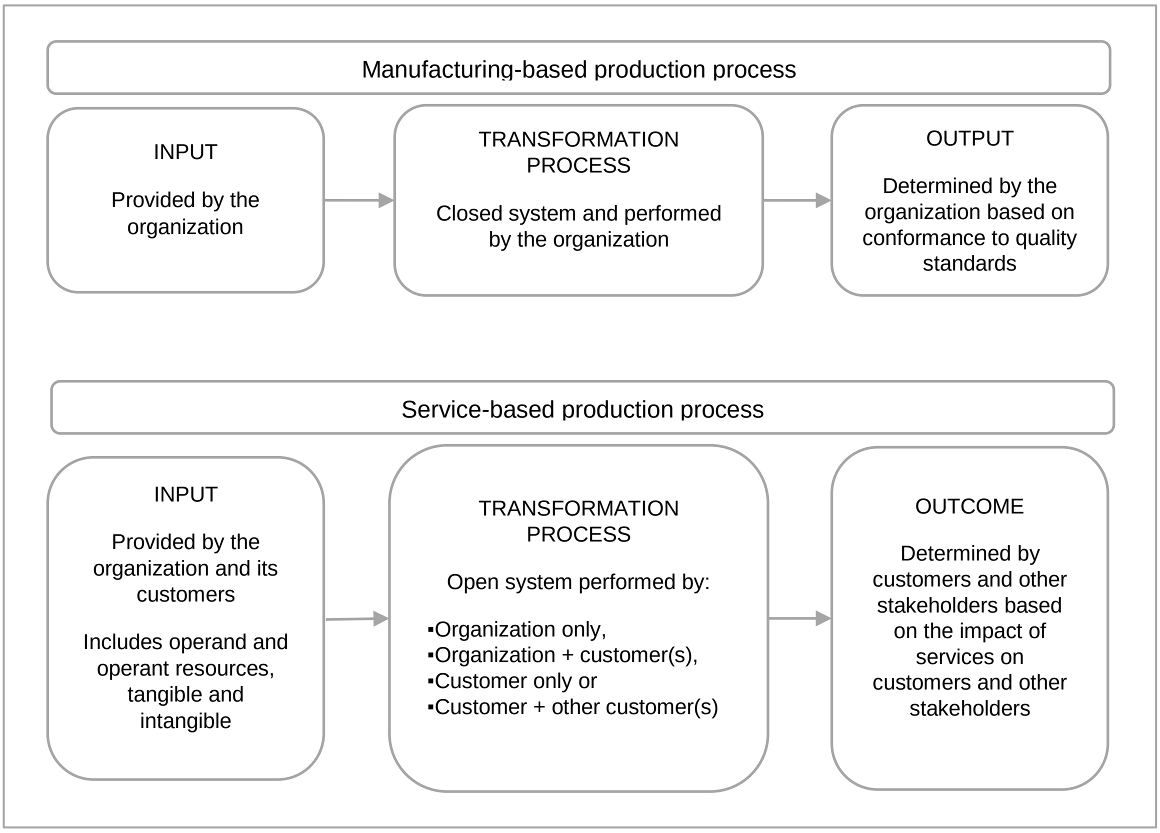


*Figure 4 - Differences between manufacturing-based production processes and service-based production processes by Yalley and Sekhon (2014)*

Continuing the discussion on differentiating service productivity from the traditional manufacturing-based productivity models, Yalley and Sekhon (2014) focused on studying the service production process and its implications to service productivity, and proposed a framework that illustrates the relationship between service production process and service productivity. They first highlighted the differences in the production processes between traditional manufacturing and services (see Figure 4), resulting in similar findings to those of Grönroos and Ojasalo (2004). It is evident that the role of customers is emphasized in every step of the production process, as service production process is again considered an open system instead of a closed one, where customers provide input, participate in the transformation process and determine the value and quality of the service in use. The doctrines of service-dominant logic (Vargo and Lusch, 2004) are strongly embedded in the framework; value is always co-created with customers who provide operand (tangible) and operant (intangible) resources, and value is always determined by the beneficiary, that is, customers and other stakeholders who derive value from the provided service.

The schematic framework by Yalley and Sekhon (2014) in Figure 5 illustrates the implications of service production process to service productivity. The schematic is in concordance with the previously discussed notions, in that inputs are divided into producer and customer inputs, the transformation process is divided into multiple processes based on differing amounts of customer and/or producer input and participation, and output is divided into quantity and quality, which are denoted as efficiency and effectiveness respectively. In manufacturing-based productivity models, productivity is mainly considered an efficiency problem, meaning the focus is on optimizing the output to input quantity ratios while output quality is considered constant. Since output quality in service production is not considered constant, productivity also becomes an effectiveness problem, which comprises the provider’s ability to produce outcomes which are perceived as high quality by its customers. They further emphasize the role of technology and co-production readiness as key determinants of productivity in the transformation process, as they help effectively allocate and coordinate required resources to be transformed into valuable outcomes.

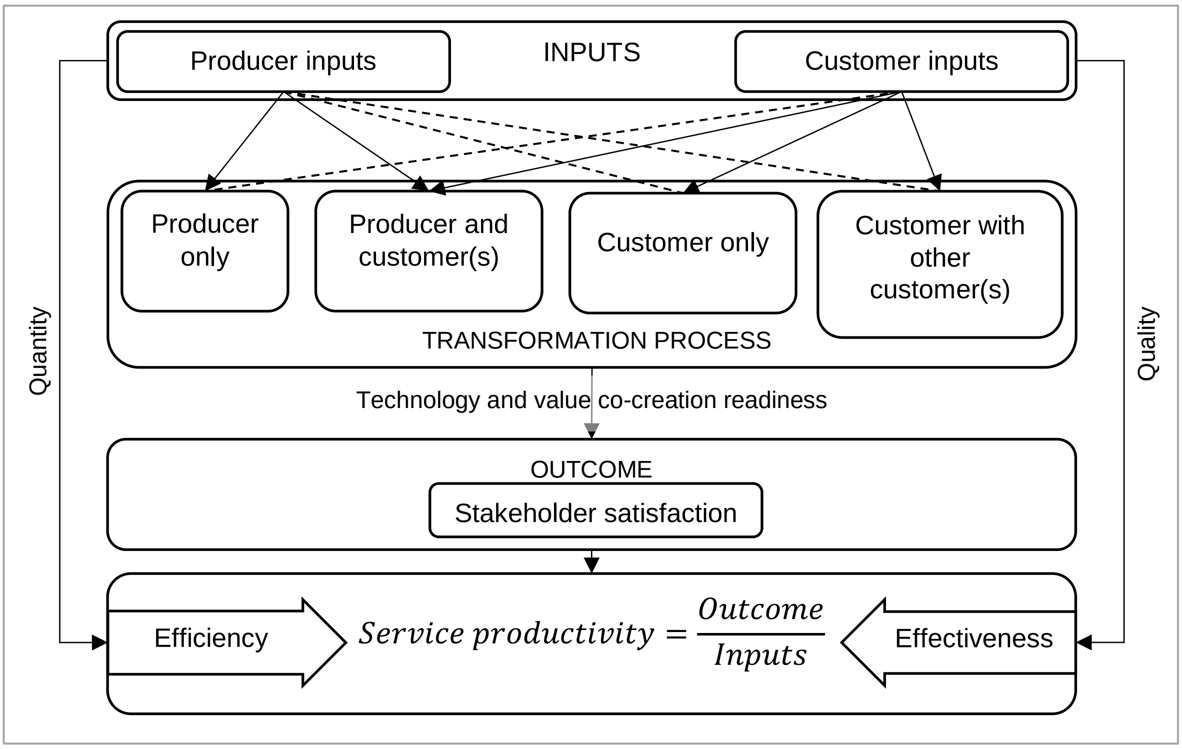


*Figure 5 - The service production process and its relationship with service productivity by Yalley and Sekhon (2014)*

To conclude, the characteristics of services and service consumption clearly cause the concept of service productivity to diverge from the traditional manufacturing-based productivity concept. Service production is an open process where customers participate as resource providers and co-producers of value. It is therefore important to understand their contribution to the productivity equation and developing customers' readiness to provide higher quality inputs should be seen as an option to enhance service productivity. Managing service productivity requires balancing efficiency and effectiveness, as changes in the service provider's input structure can affect customers' quality perceptions of the service. Further, as service consumption is considered process consumption, that is, customers experience the quality of the production process in addition to the outcome of that process, effectiveness must be expanded to include the quality of the production process. Next, the role of service quality and its implications to service productivity are discussed in more detail.

## *2.3 Service quality*

In contrast to manufacturing, in services customers experience at least some portion of the production process and its quality, in addition to the quality of the outcome of that process. Thus, for the customer to have a good service experience, the service must lead to both good quality of the outcome and good quality of the process (Grönroos, 1998). To illustrate, customers of a restaurant expect enough good quality food for a reasonable price as an outcome, but when they assess the overall experience, factors like the quality of customer service, hospitality and atmosphere are also important, which are considered parts of the service production process. The quality of the outcome, denoted as technical quality, and the quality of the process, denoted as the functional quality, equal the overall experienced service quality. Since services are more or less produced in interaction between providers and customers, and customers' assessment of quality is largely subjective due to the intangibility of services, output quality can vary significantly between customers and transactions (Ojasalo, 1999, 61).

Perceived service quality is considered critical to service productivity management because, unlike in manufacturing, internal efficiency is inseparable from external efficiency, that is, perceived service quality (Grönroos and Ojasalo, 2004). The assumption of constant output quality does not hold in services because even if the technical quality could be held unchanged, reducing company inputs to cut costs will likely be reflected in the functional quality of that service. Because service production processes are open processes where the customer sees and experiences how the process functions and interacts with the service provider's resources, the provider must manage both the service process and all resources needed in that process to create good perceived service quality (Grönroos, 1998). As a result, service providers have a strategic imperative to simultaneously pursue both improved productivity and customer satisfaction (Lee, Patterson and Ngo, 2017).

Grönroos (1984; 1990, p. 47) illustrated how perceived service quality is constructed from a services marketing perspective and established a perceived service quality model (see Figure 6). The model states that quality perception is a function of both the customer's expectations of the service and the actual experience of consuming that service. What the customer expects from the service may depend on what is communicated to customers through marketing channels, the company's image, word-of-mouth and the actual customer needs. In other words, the customer's expectations are based on promises about the service offering that are given through different channels, typically through the company's own marketing and other customers' endorsement.

The quality of the actual service experience is constructed from the two dimensions mentioned earlier; the technical quality of the service which is the outcome, and the functional quality which is the process. Thus, in terms of the overall service experience, what matters is both *what* the customer receives and *how* the customer receives it. The experience is further influenced by the customer's sentiment on the company image; the technical and functional quality dimensions are filtered through the company's image which influences the quality perception either favorably, neutrally or negatively, depending on the customer's opinion on how good or bad the company is.

Finally, having experienced both the process and outcome of the service, customers compare the experienced service to their expectations to form the conclusive quality perception of that service. In other words, customers are given promises, and the service provider is then expected to keep those promises by providing adequate service quality to meet those expectations. If a noticeable negative gap exists between the expectations and what is received, customers are left disappointed as the perceived service quality is unsatisfactory.

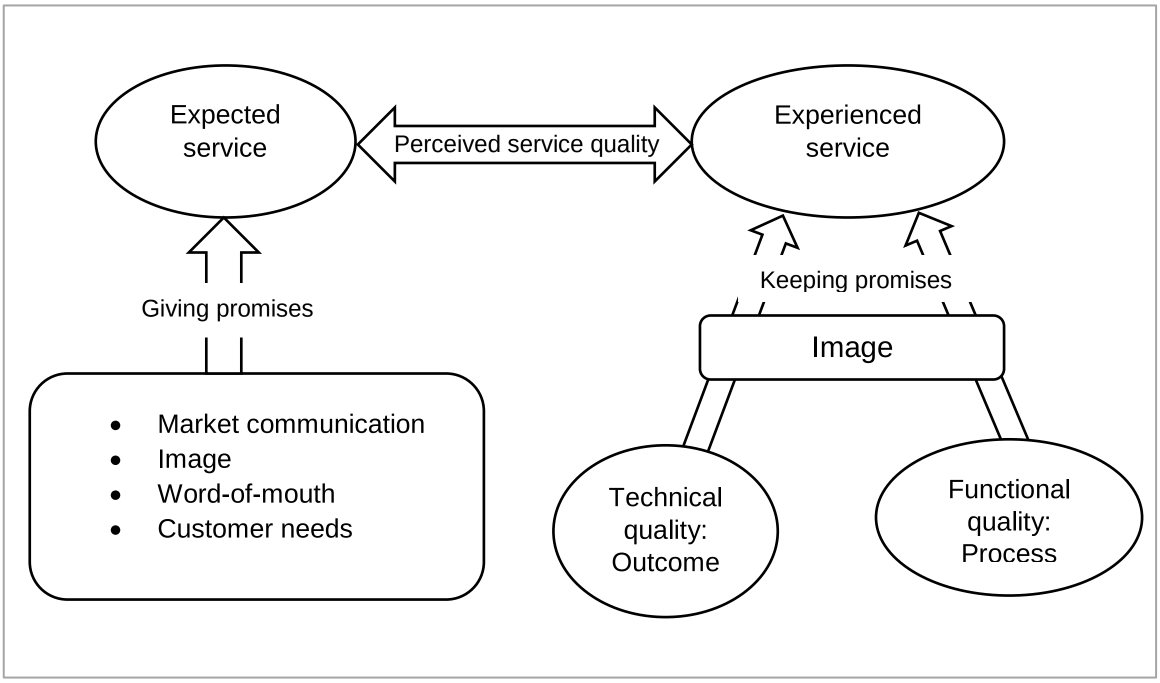


*Figure 6 - A perceived service quality model by Grönroos (1984)*

From a service productivity perspective, the better the perceived quality that is produced using a given amount of inputs from the provider and the customer, the better the external efficiency and consequently service productivity (Grönroos and Ojasalo, 2004). Further, what affects the quality perception is the proportion of company inputs to customer inputs. Parasuraman (2010) expanded the service productivity concept by developing a dual-perspective framework of service productivity (see Figure 7), where service quality is the core element linking the provider and customer perspectives to quality and productivity. A major implication of the framework suggests that service quality is negatively correlated with the amount of customer inputs and positively correlated with provider inputs. When more customer inputs are required, that is, when customers must spend more of their time and effort to produce the service, their quality perception of the service is diminished. By increasing the amount of provider inputs, the inputs required from customers to produce the service should decline and consequently, customer perceived service quality should improve.

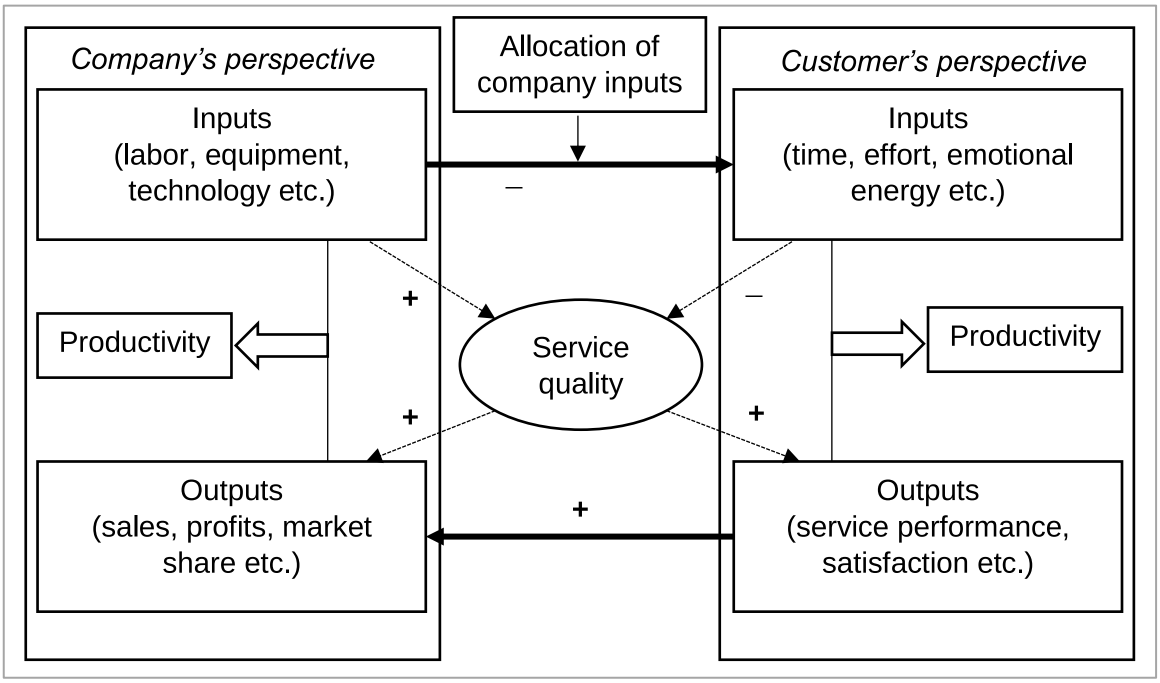


*Figure 7 - A dual-perspective framework of service productivity by Parasuraman (2010)*

However, Parasuraman (2010) emphasizes that increasing provider inputs without a careful consideration of meaningful allocation of those resources might even worsen the customer's quality perception, especially if the provider ignores critical customer needs and instead allocates its resources to functions that bring little value to its customers. Managers should thus focus on understanding their customers' needs and expectations and then translating them to service standards before allocating critical resources elsewhere. Finally, in accordance with Ojasalo (1999, 71), the framework by Parasuraman (2010) suggests that higher service quality first contributes to customer-side outputs, that is, higher satisfaction and performance, which in turn contribute to provider-side outputs, such as higher market share and revenues as new customers can be attracted more easily, and existing customers are retained.

Customer retention has further implications regarding service quality and productivity. Grönroos and Ojasalo (2004) stress the notion that internal and external efficiencies can be developed favorably through long lasting customer relationships, which enable the provider and the customer to interact and establish mutual understanding of how to produce and consume the service. Therefore, customer relationships can be considered mutual learning experiences, where through relationship continuity, customers may acquire competencies to perform parts of the process more efficiently and their expectations about the service will align better with the service provider's offering. As a result, customer perceived service quality and service productivity are expected to improve (Ojasalo, 1999, 193). Offering service quality that competition cannot match provides the basis for enhanced loyalty, retention and improved business performance (Ennew and Binks, 1996). High customer defection rates result in situations where any major benefits from learning effects are difficult to obtain as the competence gap between the provider and its customers is constantly broad, which in turn results in low service productivity (Grönroos and Ojasalo, 2004).

To conclude, service quality comprises both the outcome and the process of producing and delivering the service, which diverges from the traditional product-centric view where only the quality of the end product matters. As service production processes are considered open processes, that is, customers more or less participate in the production process and experience its quality, firms must expand their quality considerations to include at least parts of the process that are visible to customers. Customers then form the decisive quality perception by comparing their expectations of the service to the actual experience they receive. Therefore, to avoid major quality gaps, firms should strive to understand their customers' needs and expectations and then adjust their service to meet those expectations. If customer perceived service quality is high, customer defection rate is likely to be lower and consequently, external efficiency will be higher through increased market share and revenues.

## *2.4 The productivity-quality trade-off*

As stated earlier, the traditional view to productivity is normally represented as “the effective transformation of input resources into outputs, the quality of which is unchanged” (Grönroos and Ojasalo, 2004). Again, in a manufacturing context it is reasonable to assume that the input structure and the production process can be modified without affecting the customers’ quality perceptions, because customers only experience the quality of the output, typically a physical product which passes through quality control before reaching the customer. Because of this constant quality assumption, changes to the inputs and the process that increase cost efficiency can be expected to increase productivity, as the products can be expected to generate the same level of revenue as before (Grönroos and Ojasalo, 2015). In other words, productivity measured by output-to-input ratios can be assumed to improve only if the quality of output remains unchanged (Calabrese, 2012).

In principle, it is always desirable to have service that is both more efficient and more effective (Rust and Huang, 2012). However, the problem with service provision is that productivity and perceived service quality are inseparable phenomena; in services a changed set of inputs easily alters the perceived quality of both the outcome and the process (Grönroos and Ojasalo, 2004). Because service processes are open processes, customers perceive how changes in the inputs and processes influence the quality level of the service (Grönroos and Ojasalo, 2015). Therefore, attempts to increase productivity by focusing on internal efficiency may have an adverse effect on service quality and consequently on the company’s revenue generating capability. If the perceived service quality declines, the customers’ willingness to pay for the service also declines and as a result, revenues are probably lost (Grönroos and Ojasalo, 2015).

This interrelationship between efficiency and effectiveness is often referred to as the trade-off effect of service productivity (Rust and Huang, 2012). The basic assumption of this trade-off effect is that improving internal efficiency by introducing more cost effective and ostensibly more productive resources and processes does not necessarily lead to improved economic results (Anderson, Fornell and Rust, 1994; Grönroos and Ojasalo, 2004; Kowalkowski, 2008; Rust and Huang, 2012). If the trade-off exists, cost savings from productivity improvements may be offset by revenue losses from reduced quality and customer satisfaction (Rust and Huang, 2012), given that reduced perceived quality is likely to impair customer retention and subsequently financial performance. Thus, in services, “productivity and service quality should not be managed as separate processes” (Grönroos and Ojasalo, 2004).

Quality perceptions in services tend to correlate with investments in labor, better service typically requiring more labor intensity, which results in lower productivity due to higher costs (Huang and Rust, 2014). Thus, improving internal efficiency by reducing staff or hiring more affordable staff is likely to have an adverse effect on perceived quality. Likewise, adapting more automation to replace labor can both deteriorate the customers' quality perceptions (Rust and Huang, 2012) and increase costs through investment and maintenance costs (Kowalkowski, 2008). Whether productivity improvements by increasing internal efficiency are appropriate or not depends on the diversity of demand (Carlborg, Kindström and Kowalkowski, 2013) and how much differentiation is desired (Viitamo, 2009), because customization often requires more labor and more diverse resources. According to Anderson, Fornell and Rust (1994), productivity and customer satisfaction are more likely to be compatible when customer satisfaction is more dependent on standardization quality and for industries with a significant goods component, such as automobiles and clothing stores. When customers expect standardized service or only limited customization, that is, when diversity of demand is low, service providers can increase their cost efficiency by adjusting their input resources and increasing automation without damaging perceived quality.

On the other hand, if the service has a high diversity of demand, improving productivity by focusing on cost efficiency will likely lead to significant reduction in perceived quality and lower profitability (Anderson, Fornell and Rust, 1994). If customers expect diversity and customization quality, differentiation instead of cost leadership is likely to be a more suitable strategy, and consequently, productivity will be lower as differentiation and uniqueness lead to higher expenses (Viitamo, 2009). In other words, when customers expect more customized and personal service, emphasizing on increasing customer satisfaction might be more relevant approach (Carlborg, Kindström and Kowalkowski, 2013). Thus, to be able to make correct decisions about whether cost efficiency or quality should be prioritized, managers should understand their customers' needs regarding diversity of demand and customization. Increasing internal efficiency can then either reduce or increase customer satisfaction, depending on the circumstances (Johnston and Jones, 2004).

Managing service productivity evidently requires balancing internal efficiency and perceived quality, and understanding the strategic implications of both dimensions. Typically cost reductions lead to reduced perceived quality and to lost revenues, but if the decline in revenues is less than the cost savings, productivity improves. However, the productivity gains might be short lived, as the long term effects from reduced quality might lead to a negative image and unfavourable word-of-mouth, which can result in increasing customer defection and lost revenues (Grönroos and Ojasalo, 2004). It is therefore important to understand the potential long term effects of internal efficiency improvements to avoid this pitfall. Service quality suffers if firms blindly follow productivity improvement methods used in traditional manufacturing, but likewise, incessantly enhancing service quality is economically unsustainable unless firms have access to infinite resources (Parasuraman, 2010). On the other hand, internal and external efficiencies can be concurrently improved if firms can introduce more cost effective input resources or processes that are simultaneously quality maintaining or enhancing (Grönroos and Ojasalo, 2015), such as some internet-based process innovations and computerization (Filiatrault, Harvey and Chebat, 1996).

In conclusion, the notion that productivity and quality are inseparable in services derives from the fact that provider inputs and processes are often more or less visible to customers, and hence changes to those inputs and processes will affect the customers' quality perceptions. As a result, productivity improvements have the potential to impair perceived service quality so that the productivity gains are offset by the reduced revenue generating capability. Reduced service quality can further undermine the company's image and reputation in the long run, hence managers should be wary of compromising perceived quality for internal efficiency and quick wins. It is thus important to acknowledge this trade-off effect between productivity and quality when managing service productivity.

## *2.5 Human resources*

Due to the characteristics of services and how services are consumed, a successful service production process is largely dependent on the employees interacting with the customer (Kowalkowski, 2008). As service processes are considered open processes where the customer interacts with the service provider's input resources, which contributes to the overall perceived quality of the service, employees typically comprising a significant part of the input resources indicates they have a crucial role in the quality and productivity equations. Hence, the role of human resources is discussed in this section.

In manufacturing where the flow of materials through a system can be controlled and held at a constant rate, it is generally assumed that assigning employees a limited set of tasks is more productive than having a broad set of tasks, which derives from assembly line production where only parts of the products are assembled by employees (Johnston and

Jones, 2004). However, since most services are produced and consumed simultaneously and often face uneven demand, limiting the skills and tasks of employees might not be the most productive approach in services.

Ojasalo (1999, 175) suggests that a broad array of tasks for which service employees are qualified can significantly affect productivity through more efficient use of labor, as employee downtime can be reduced and less outside workforce and subcontracting is needed. For example, a hotel is likely to experience fluctuating demand in different parts of its services during one day; the reception typically experiences high demand in the mornings and late afternoons, while the bar and restaurant will be crowded in the evenings. By multi-skilling the hotel employees so that they can work where they are needed most, fewer core staff is needed, the staff utilization is higher and external efficiency is increased, for example, through less waiting time for customers (Johnston and Jones, 2004). Thus, service providers should consider if multi-skilling their staff could provide increased productivity through better capacity utilization and efficiency, which in turn can increase external efficiency when more customers can be served on schedule.

In addition to employees' skills, what affects their productivity is their motivation to perform their work related tasks to their best ability. The quality and motivation of the labor force can significantly impact service productivity, as they can directly affect customer perceived service quality (Ojasalo, 1999, 178-179). According to Calabrese (2012), leveraging on human resources, that is, improving employees' abilities, competences and motivations, is the only way to simultaneously increase both service productivity and service quality if technical efficiency is assumed. Technical efficiency in this context means that all technological and organizational resources, such as information technologies and business processes, are assumed to be fully employed and efficient. A firm might have the technologies and knowledge required to create a good outcome of a service process, but if employees lack the skills and motivation necessary to implement the process efficiently the quality of the outcome will suffer (Grönroos, 1998). Therefore, managers should pay attention to their employees' work motivations and factors affecting those motivations also when productivity is considered.

Employees' motivation comprises two parts; first their motivation to act and then their motivation to act to accomplish company goals. Maslow's needs theory has been used to explain the first part, from which can be inferred that employees' motivations can be improved if they have fair wages, a supportive team and feedback mechanisms connected to their work performance. In other words, if their basic needs concerning the work environment and rewards are fulfilled, they move higher on the needs hierarchy and are more motivated to place efforts on performing well. Examples of these motivational drivers include monetary incentives, team building and objective performance measures. The motivation to act towards accomplishing company goals is explained through three choice theories; the expectation theory which assumes that employee commitment depends on their expectations about rewards related to their achievements, the fairness theory which states that employees adjust their commitment based on their performance evaluation compared to other employees' performance evaluation, and finally, the goal setting theory which states that clear and challenging goals motivate employees to pursue company goals by increasing their interest towards them. (Calabrese, 2012)

In their study, Lee, Patterson and Ngo (2017) studied the drivers of employee productivity and their findings indicate that productivity is influenced by employees' perceptions of their own skills and abilities (self-efficacy) and employee engagement, that is, the attention, energy and devotion they display while performing their work-related tasks. Their results further indicate that both self-efficacy and engagement are positively influenced by job resources, such as working relationships with the supervisor, team support, performance feedback, development opportunities and other job-specific resources that affect the employee's perceptions of the workplace. They conclude that service firms that invest in good social relations in the workplace such as teamwork can improve both employee productivity and customer satisfaction, thus refuting the trade-off effect of service productivity.

Similarly, the study by Sekhon et al. (2016) indicates that when firms allocate tangible and intangible resources to employees' activities, their preparedness to perform their tasks successfully is improved and, subsequently, productivity is improved. Therefore, managers should see that they can provide a hospitable and supportive work environment to their employees as it forms the basis for better performance and higher productivity among employees.

Further, Calabrese (2012) proposes three non-conflicting and self-reinforcing dimensions through which people are motivated and which can be activated by company managers, shown in Figure 8. The functional dimension comprises primary needs, such as salaries and monetary incentives, and can be employed by organizational rules, such as hierarchies, technologies, salaries and incentive systems. The relational dimension considers psychical aspects of the workplace, such as relations with the supervisor and colleagues, and is mainly activated by the organizational climate. Finally, the meaning dimension considers the sense of purpose employees experience in their work, which could be activated by establishing a meaningful vision and strategy for the organization.

Accordingly, managers can utilize these motivational activators to increase employee motivation and productivity. Monetary incentives alone can overcome the productivity-quality trade-off in services (Calabrese and Spadoni, 2013), but both the relational and meaning dimensions offer additional insight and options for managers to enhance service productivity through more efficient use of employees' resources without sacrificing service quality. Thus, Calabrese (2012) extends the service productivity function of Grönroos and Ojasalo (2004) to also include *meaning efficiency* as a fourth dimension of service productivity:

$$Service\ productivity = f(Internal\ efficiency, External\ efficiency, Capacity\ efficiency, Meaning\ efficiency)$$

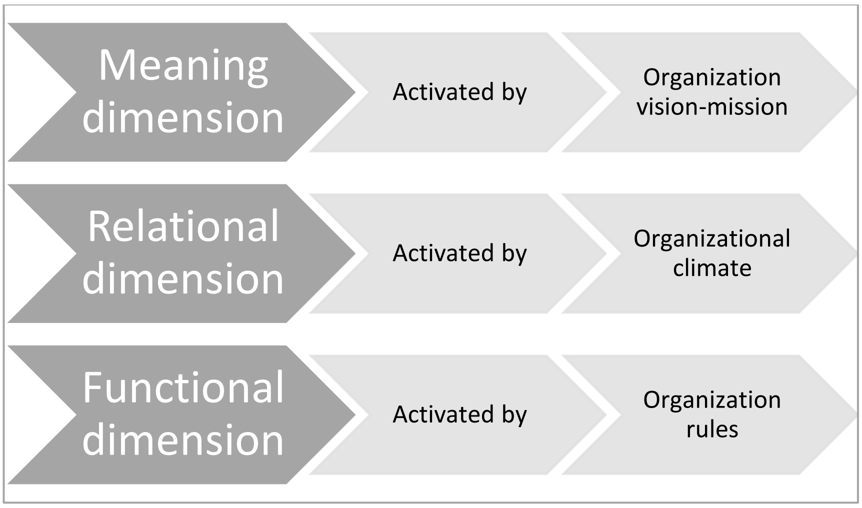


*Figure 8 - Motivational dimensions and their organizational activators by Calabrese (2012)*

To conclude, as service processes are typically dependent on employees and their interaction with customers, human resources have a significant impact on service productivity in terms of both cost efficiency and customer perceived quality. Arguably, in some services the employee-customer interaction can form the major part of the customer's quality perception of the service. Further, labor often comprises one of the largest expenses of a company, especially in the services sector. To enhance capacity utilization, service companies can consider multi-skilling their staff which enables more flexible allocation of resources to better meet fluctuating demand and customer flow.

Employee productivity is dependent on their skills but also on their motivation to perform their tasks efficiently and effectively. Thus, managers should first ensure that the primary needs of their employees, such as fair and equal compensation, objective performance measures and feedback, are fulfilled so that the fundamentals for better motivation are established. Then, to further enhance employees' motivation to act towards accomplishing company goals, managers should ensure that the organizational climate is supportive by establishing good relations with subordinates and by fostering team building. Finally, when the aforementioned dimensions are fulfilled, establishing a meaningful company vision and assigning employees tasks to realize that vision can further reinforce motivation by giving employees a sense of purpose in their work.

## *2.6 Optimal service productivity*

Having discussed the characteristics of services and service productivity, we established an understanding of how service productivity is constructed and how it diverges from the traditional view to productivity. It is evident that in services, productivity and service quality are often interdependent which can at worst result in detrimental trade-off effects. It is then reasonable to discuss if there exists an optimal level of productivity for a given company or a service, and if so, how the optimal level of productivity can be determined. The following section will focus on answering these questions.

From a manufacturing perspective, high productivity is generally considered advantageous as it translates to lower costs (Johnston and Jones, 2004) without compromising output quality. Therefore, a manufacturing company might perceive productivity as a variable to be maximized for enhanced profitability. However, because productivity and quality are interdependent in services, service companies should view productivity as a strategic decision variable, the optimal level of which depends on factors such as the business, the market environment and technology (Huang and Rust, 2014). Moreover, since service productivity must be balanced with customer perceived quality (Kowalkowski, 2008), what affects the optimal level of service productivity is the relative importance of customer satisfaction, that is, when customer satisfaction is more important for profitability than efficiency, the optimal productivity level should probably be lower and vice versa (Huang and Rust, 2014). The key problem of optimizing service productivity is then how to most profitably serve the customer, that is, what level of service productivity maximizes profits (Rust and Huang, 2012).

According to the service productivity model by Ojasalo (1999, 71) discussed earlier in this study, service providers can manage service productivity by balancing between the three dimensions of service productivity, namely the internal efficiency, external efficiency and capacity efficiency. The relative importance of customer satisfaction should then shift the optimal balance between these dimensions where profitability is maximized. Further, according to Huang and Rust (2014), the level of technology affects the optimal level of productivity because more advanced technology can better substitute labor and yield cost savings without damaging service quality. Technology and automation are thus key factors for managing internal efficiency and capacity efficiency. The remainder of this section discusses the optimization of service productivity from three perspectives. First, technology and automation are discussed as a means to improve and optimize service productivity. Then, the impact of the market- and business characteristics to optimal service productivity are discussed. Finally, optimizing capacity and demand are discussed.

### *2.6.1 Technology and automation*

Ojasalo (1999, 167) lists three basic ways in which technology can be used to improve service productivity: improving the efficiency of back-office tasks performed by employees, improving the efficiency of front-line employees and their interaction with customers and finally, allowing customers to perform services for themselves using technology. Many administrative back-office tasks are non-value-adding and invisible to customers, hence their efficiency can often be improved to reduce costs and to increase flow without damaging service quality (Kowalkowski, 2008).

Technological solutions and innovations can improve front-line employee efficiency by making employee-customer interactions more efficient and effective, but also by making internal tasks such as documentation and invoicing more efficient. Examples of such solutions include handheld devices (PDAs) for service technicians where administrative tasks can be performed efficiently, which can significantly improve internal efficiency through reduced administrative costs (Kowalkowski, 2008). Technology also enables self-service solutions that reduce labor requirements as customers can perform services or parts of them on their own, such as through the internet or self-service counters at the airport and grocery stores (Rust and Huang, 2012).

Investments in technology should be planned and targeted to processes that either add substantial value to customers or significantly reduce operating costs, as automating minor processes may only add to a system's complexity and undermine productivity (Ojasalo, 1999, 171). Further, companies should carefully project the impact of automating processes involving customer contact on customer satisfaction and productivity to avoid damaging profitability by reducing customer perceived quality excessively (Huang and Rust, 2014). Despite the fact that such trade-off effects often exist for services, some technology applications can simultaneously reduce costs and improve perceived quality, resulting in a win-win situation (Anderson et al., 1997; Kowalkowski, 2008; Parasuraman, 2010). Thus, technology and automation can offer significant service productivity improvements if targeted and implemented sensibly.

Because of the trade-off between automation and service quality, managers need to decide how much automation can be employed to maximize profitability. In their study, Rust and Huang (2012) showed that the optimal level of productivity is dependent on the level of technology, which increases over time. More specifically, there is an inverted U-shaped relationship between productivity and profitability (see Figure 9) which indicates that for any given time and level of technology there exists an optimal level of productivity, which changes over time as the level of technology advances. The implication is that as technology advances, more suitable and efficient technological solutions and innovations emerge that allow automating processes without compromising perceived service quality. The optimal service productivity level is therefore a moving target, which challenges managers to periodically reassess their service productivity decision making as technology advances (Rust and Huang, 2012).

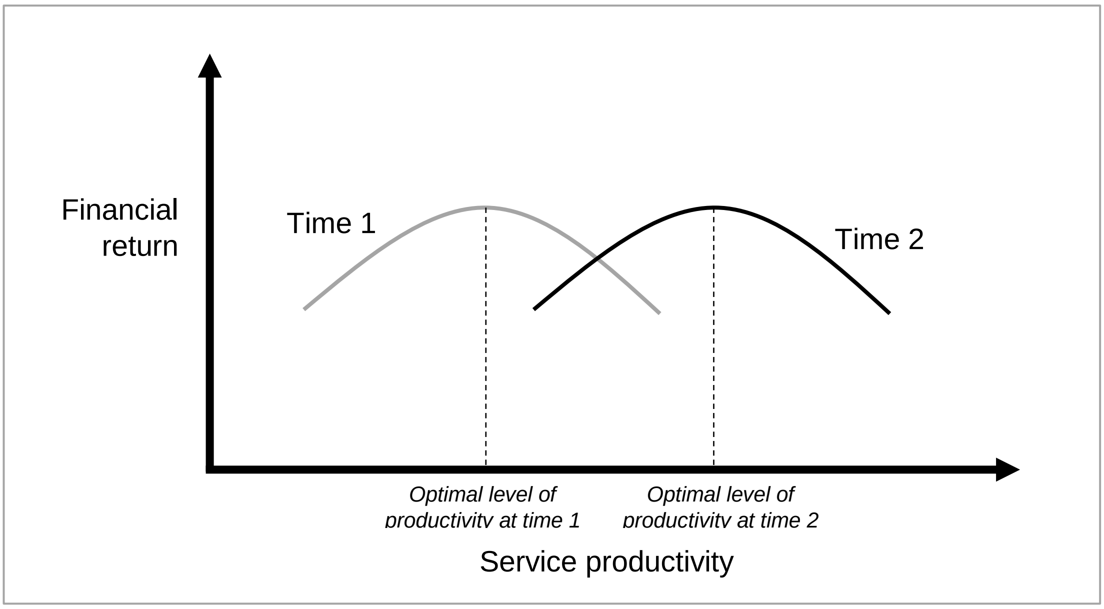


*Figure 9 - The relationship between productivity and profitability in a service company by Rust and Huang (2012)*

### *2.6.2 The relative importance of customer satisfaction*

In addition to the level of technology, the optimal level of productivity is affected by firm- and industry-specific factors related to the business and market environment of any given service provider. According to Rust and Huang (2012), four major determinants, namely profit margins, price, market concentration and wages affect the optimal level of productivity by influencing the relative importance of service quality. Their study found that higher profit margins and higher prices negatively impact the optimal level of service productivity; when prices and margins rise, unit sales are worth more which justifies a higher level of service quality to increase unit sales. As providing higher service quality typically requires more labor and other resources, service productivity should consequently be lower.

On the other hand, higher market concentration and higher wages positively impact the optimal level of service productivity. When market concentration is high, that is, when there are few competitors and thus customers have fewer alternatives, service quality is likely to be less important as customers are less likely to switch suppliers. Consequently, less labor and more automation can be employed to improve productivity. Further, when providing higher quality service depends on labor, as wages get higher productivity becomes more of a priority because providing better service quality becomes increasingly expensive. Thus, higher wages encourage companies to increase service productivity and the optimal level of productivity is higher. Additionally, when factors other than service quality become more influential in driving sales, such as advertising and brand equity, service quality becomes less important and again, the optimal level of service productivity increases. (Rust and Huang, 2012)

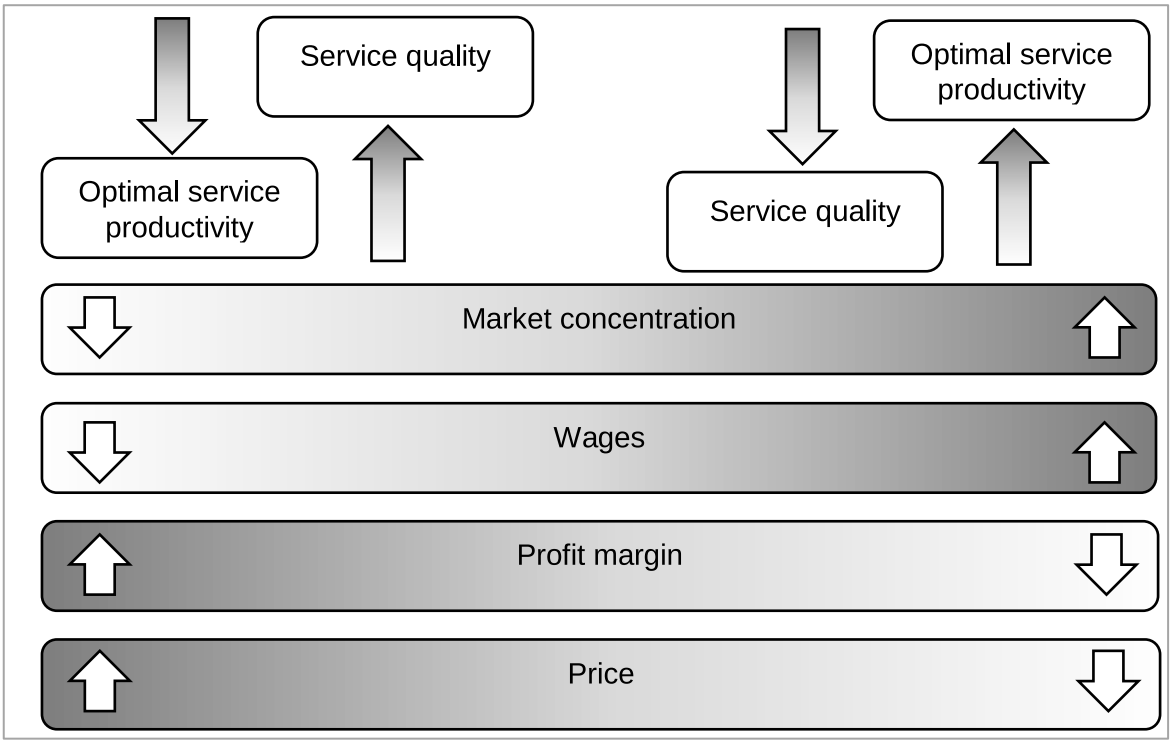


*Figure 10 - Industry- and market-specific factors affecting the optimal level of service productivity, adapted from Huang and Rust (2014)*

In sum, higher profit margins and prices reduce the optimal level of productivity, while higher market concentration and wages increase the optimal level of productivity (see Figure 10). The reasons behind these effects lie in the relative importance of customer satisfaction; when factors motivate companies to increase service quality, service productivity should be lower and vice versa (Rust and Huang, 2012). In determining what productivity level to seek, companies can strategically compare themselves to their competitors to see if profit margins, prices or wages differ considerably and then decide whether increasing productivity or offering better service quality is strategically more appropriate (Huang and Rust, 2014).

### *2.6.3 Capacity and demand*

Previously we established that services face the challenge of balancing capacity with fluctuating demand as most services are produced and consumed simultaneously, that is, they cannot be produced in advanced and warehoused for later consumption like physical products. Further, because successful service production is typically dependent on expensive labor, capacity optimization is a critical element of service productivity optimization as it affects both cost-efficiency and service quality. Both excess capacity and excess demand impair service productivity; excess capacity reduces internal efficiency as the accumulated costs undermine profitability, while excess demand reduces external efficiency through increased waiting times for customers. Thus, the goal of capacity optimization is to find a balance between perceived service quality (external efficiency) and internal efficiency (Grönroos and Ojasalo, 2004).

Ideally then, to optimize service productivity, demand and capacity should always be at perfect balance so that capacity utilization and customer perceived quality are maximized. In reality, service companies face more or less fluctuating demand and capacity constraints that lead companies to make compromises considering their production capacity. Arguably, the relative importance of customer satisfaction should have an influence on whether a company's capacity should lean more towards better productivity (less labor) or better service quality (more labor). According to Rust and Huang (2012), when demand exceeds capacity, optimal productivity should be higher and less labor can be employed because the company does not need more labor to drive demand and sales, that is, customer satisfaction is less important for profitability. On the other hand, they state that if maintaining customer satisfaction is strategically important, instead of reducing capacity the company should increase price and keep capacity and perceived quality constant, such as during high demand seasons such as holiday seasons in skiing resorts. Therefore, capacity decisions should also be proportioned to the relative importance of customer satisfaction.

In addition to decisions considering absolute capacity, that is, how many employees are hired to produce a service, managers should think how the capacity is best utilized. As discussed earlier, multi-skilling employees can yield productivity improvements because it enables flexibly allocating resources from low-demand- to high-demand areas within the company's service operations, which allows the company to better meet fluctuating demand without hiring more labor (Johnston and Jones, 2004). Multi-skilling can thus be used to optimize capacity utilization by reducing idling among employees and by responding more dynamically to demand fluctuations.

To balance capacity and demand, in addition to managing their production capacity companies may also manage their demand. Service providers face challenges in balancing capacity and demand because customer flow is difficult to predict and control, which makes it challenging to have the right amount of employees for every demand peak and valley so that capacity utilization is optimal. To manage their demand, service companies can utilize arrangements such as service level agreements (SLA) and preventive maintenance contracts through which companies are able to do advanced planning and disperse their workload to some extent, which enables better capacity utilization (Kowalkowski, 2008; Carlborg, Kindström and Kowalkowski, 2013). For example, conducting regular preventive maintenance on elevators is likely to reduce unexpected malfunctions, which results in better predictability of demand for the maintenance service company, allowing them to forecast labor requirements and achieve better balance between capacity and demand.

*Table 1 - Optimum capacity utilization by Ojasalo (1999, 127)*

| | **Output quantity** | **Output quality** |
|---|---|---|
| **Optimum capacity utilization** | Positive influence | Positive influence |
| **Low capacity, excess demand** | Positive influence (but loss of business) | Negative influence |
| **Low demand, excess capacity** | Negative influence (unsustainable in long term) | Positive influence (possible bad signals) |

It is evident that both excess demand and excess capacity cause problems considering optimal service productivity where the objective is to find a balance between output quantity and output quality. Companies can make compromises considering their capacity based on the relative importance of customer satisfaction, but as stated by Ojasalo (1999, 127), the target in services should be *optimum capacity utilization*, meaning that personnel and equipment are used so that there is enough time for equipment maintenance and employees are not exhausted by excess workload (see Table 1). At optimum capacity both output quantity and quality are in balance, that is, demand does not exceed capacity so much that quality is adversely affected, or capacity does not exceed demand so much that costs impact profitability inordinately.

## *2.7 Conclusions on service productivity*

Productivity is evidently a more complex concept in services compared to the traditional manufacturing-based view to productivity. The characteristics of services, how services are consumed and customer involvement in the production process differentiate service productivity from manufacturing to the extent that some traditional productivity improvement methods are rendered ineffective or detrimental for service productivity. Managing service productivity is a balancing act between cost-efficiency (internal efficiency), service quality (external efficiency) and production capacity (capacity efficiency). Additionally, service productivity can be enhanced by driving employee motivation through fair compensation, incentives and providing meaningful tasks that give employees a sense of purpose in their work (meaning efficiency).

Optimizing service productivity involves determining the relative importance of customer satisfaction and the current level of technology. The relationship between these factors determines how productive a service should be to maximize profitability, that is, how much automation can be employed without damaging profitability through reduced service quality and lost customers. Managers must be aware of the potential trade-off between productivity and quality if productivity is viewed only from the producer’s perspective and pursued through aggressive cost reductions. The relationship between internal efficiency and external efficiency must be realized and the effects of cost reduction actions to service quality must be carefully considered to avoid damaging long term profitability.

# 3. IMPROVING SERVICE PRODUCTIVITY

Now that we have established an understanding of what service productivity encompasses, the next step is to discuss what actions companies can take to meaningfully improve their service productivity. This study focuses on the identification and evaluation of improvement opportunities, and the following section discusses methods for conducting these tasks.

## *3.1 Identifying improvement opportunities – The failure modes and effects analysis*

For companies to be able to sensibly improve their productivity they first need an understanding of the prevailing state of their processes, from which inefficiencies and potential improvement opportunities can be identified. For the purpose of identifying service productivity improvement opportunities, this study focuses on utilizing the failure modes and effects analysis (FMEA) as a basis for a method to identify process inefficiencies and actions to remedy those inefficiencies.

The failure mode and effects analysis (henceforth FMEA) is a systematic method of identifying faults within designs and processes and assessing the risks associated with failures and faults (Gilchrist, 1993). The purpose of FMEA is to find, prioritize and minimize failures (Geum, Shin and Park, 2011) to improve quality and reliability and to satisfy customers (Teng and Ho, 1996). The FMEA was originally used by the US military to evaluate the impact of system and equipment failures on mission success (Teoh and Case, 2005). It was then adopted by NASA in early 1960's and used in the Apollo- and Voyager space programs among others, but later gained more popularity when the Ford Motor Company introduced it to the automotive industry in the 1970's (Gilchrist, 1993). It has since been widely accepted as a quality management and -control tool especially in manufacturing industries.

Two general types of FMEA exist; design FMEA is used to identify flaws and failures in the design of products, while process FMEA focuses on identifying failures in processes (Teoh and Case, 2005). Both methods share the same purpose of identifying failure modes, prioritizing them by assessing the associated risks and minimizing failures. FMEA has been applied to service settings for both service design (Chuang, 2007) and service process analysis (McCain, 2006; Geum, Cho and Park, 2011; Geum, Shin and Park, 2011). This study focuses on the process FMEA as it seems more suitable for the purpose of analyzing services and identifying improvement opportunities due to the process nature of services. As stated by Geum, Shin and Park (2011), the process nature of service makes it easy to adapt FMEA to services because it is based on the decomposition of a system into a logical sequence of processes.

| Process step | Failure modes | Effects | Severity | Causes | Occurrence | Current controls | Detection | RPN | Recommended actions |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |

*Figure 11 - FMEA chart structure example*

The process FMEA starts with the development of a process flow chart where the process is decomposed into a diagram of sequential steps that represents the complete process (Teng and Ho, 1996; Geum, Shin and Park, 2011). Then, potential failure modes, their causes and resulting effects are determined for each step of the process by filling the FMEA chart. Each failure mode is then ranked using three attributes; the severity of the effects, the rate of occurrence and the probability of detection. Each attribute is typically given a value on a scale from 1 to 10. Because a numerical scale alone is not very informative for ranking failure modes, the scale should be given a meaningful written definition that fits the context of the process (Teng and Ho, 1996). The three attributes are then multiplied together to calculate a risk priority number (RPN) for each failure mode, which is then used to prioritize the failure modes for decision support. The final step is the modification of the current process to mitigate or eliminate the most critical failure modes and the development of a control plan. The typical structure of an FMEA chart is shown in Figure 11. The usefulness of the FMEA is dependent on implementing this final step, as the goal of FMEA should be to modify the current design or process to eliminate the failure modes and to develop a control plan to reduce the future occurrence of the failures (Teng and Ho, 1996).

Detecting and eliminating failure modes in service processes is likely to result in productivity and quality improvement because in a service setting, a failure mode can be defined as "a potential occurrence that can cause customer dissatisfaction or decrease the customer's perceived quality" (Geum, Shin and Park, 2011). When customer effects are considered when analyzing the effects of the failure modes, companies are able to target failure modes that have significant impact on perceived quality and potentially increase their external efficiency. Therefore, FMEA offers a suitable approach to identifying service productivity improvement opportunities.

## *3.2 Evaluating identified opportunities – The analytic hierarchy process*

The traditional FMEA uses the RPN value for evaluating the criticality of each failure mode and then prioritizing them accordingly. Using the RPN for this purpose is convenient as it is easy to calculate and thus requires little effort from the team performing the analysis. However, using RPN as the sole unit of failure mode evaluation has received criticism from academics, largely because it is considered overly simplistic for decision making purposes when applied to real world scenarios (Gilchrist, 1993; Geum, Shin and Park, 2011; Brun and Savino, 2018). Liu et al. (2013) listed the major shortcomings of FMEA in their literature review (see Table 2), mainly related to issues considering the use of RPN. To address the problems regarding the shortcomings of RPN, academics have employed alternative methods for evaluating and prioritizing the identified failure modes. Numerous different methods have been used, including multiple criteria decision making (MCDM), fuzzy logic, Monte Carlo simulations and artificial intelligence (Liu et al., 2013). Examples of alternative prioritization methods are listed in Figure 12.

*Table 2 - Major shortcomings of the traditional FMEA by Liu et al. (2013)*

| |
|---|
| The relative importance among Severity, Occurrence and Detection is not taken into consideration |
| Different combinations of Severity, Occurrence and Detection may produce the same value of RPN, but their hidden risk implications may be totally different |
| The three risk factors are difficult to be precisely evaluated |
| The mathematical formula for calculating RPN is questionable and debatable |
| The conversion of scores is different for the three risk factors |
| The RPN cannot be used to measure the effectiveness of corrective actions |
| RPNs are not continuous with many holes |
| Interdependencies among various failure modes and effects are not considered |
| The mathematical form adopted for calculating the RPN is strongly sensitive to variations in risk factor evaluations |
| The RPN elements have many duplicate numbers |
| The RPN considers only three risk factors mainly in terms of safety |

This study focuses on utilizing the analytic hierarchy process (AHP) method for failure mode prioritization. The method developed by T. L. Saaty in early 1970's utilizes structural hierarchy modeling together with pairwise comparison to weight evaluation criteria and prioritize alternatives (Saaty, 1987). The method allows using multiple criteria for evaluating the alternatives, which are not limited to the three criteria used in the traditional FMEA, and it considers the relative importance of both the criteria and the alternatives. In other words, instead of only answering the question "which alternative is more important?" like the RPN does, it answers the question "which alternative is more important, and by how much?" Further, using the pairwise comparison method results in more meaningful information for decision making purposes compared to the somewhat arbitrary calculation of the RPN value. The process can be conducted using purpose-made software but also using mainstream spreadsheet software, such as Microsoft Excel, thus making the method accessible to most companies and managers.

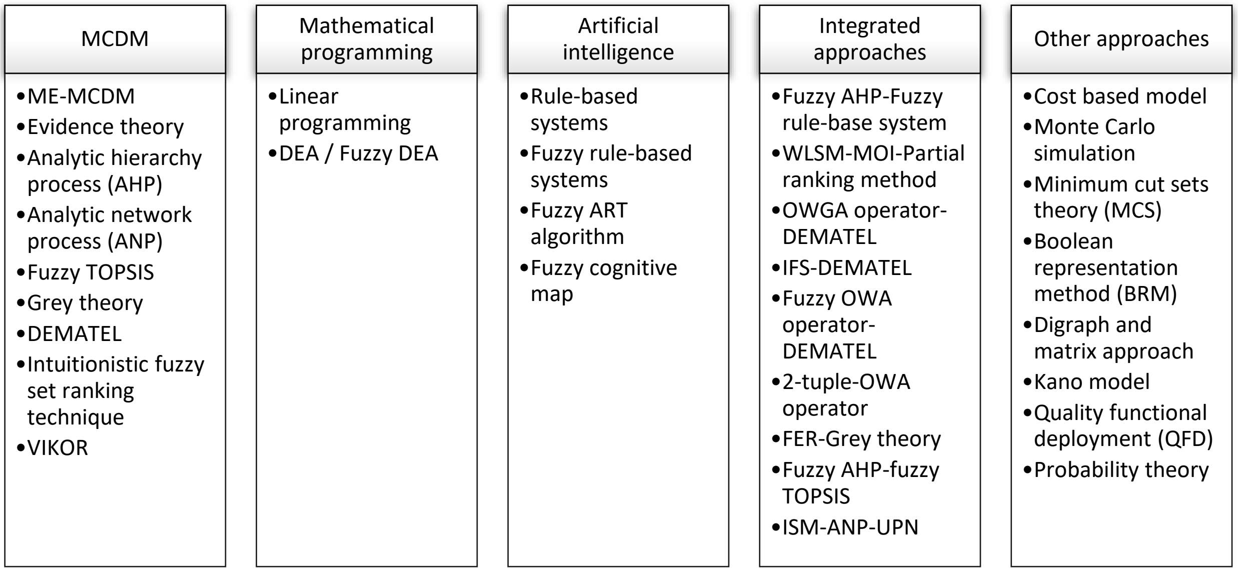


*Figure 12 - Alternative ranking and prioritization methods used with FMEA adapted from Liu et al. (2013)*

The three main operations of AHP are hierarchy construction, priority analysis and consistency verification (Ho et al., 2006). A flowchart of the AHP is shown in Figure 13. The multiple criteria decision problem is first decomposed into its components and all individual criteria and alternatives are arranged into hierarchical levels, such as in the example shown in Figure 14. All criteria are then compared in a pairwise matrix to determine the relative importance of the criteria with respect to the goal. The pairwise comparison is conducted by asking the question "how many times is criterion *i* preferred over criterion *j*?". The answer is given using Saaty's fundamental scale shown in Appendix 1. Then, all alternatives are compared pairwise with respect to each criterion on the higher level of the hierarchy using the same preference intensity scale. Each pairwise matrix is checked for consistency by calculating Saaty's consistency ratio (CR). The result of the process is a priority value for each alternative which is then used to order the alternatives for decision making support.

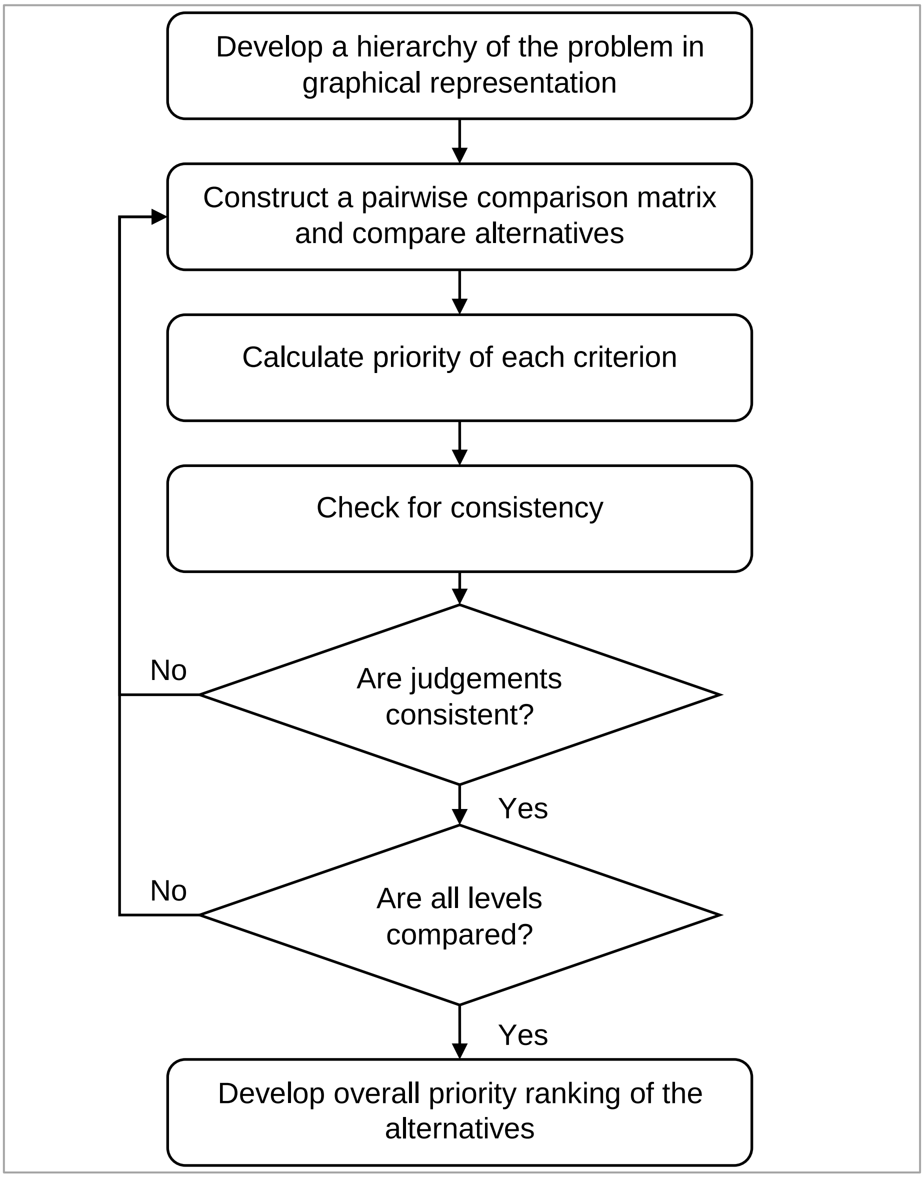


*Figure 13 - A flowchart of the analytic hierarchy process*

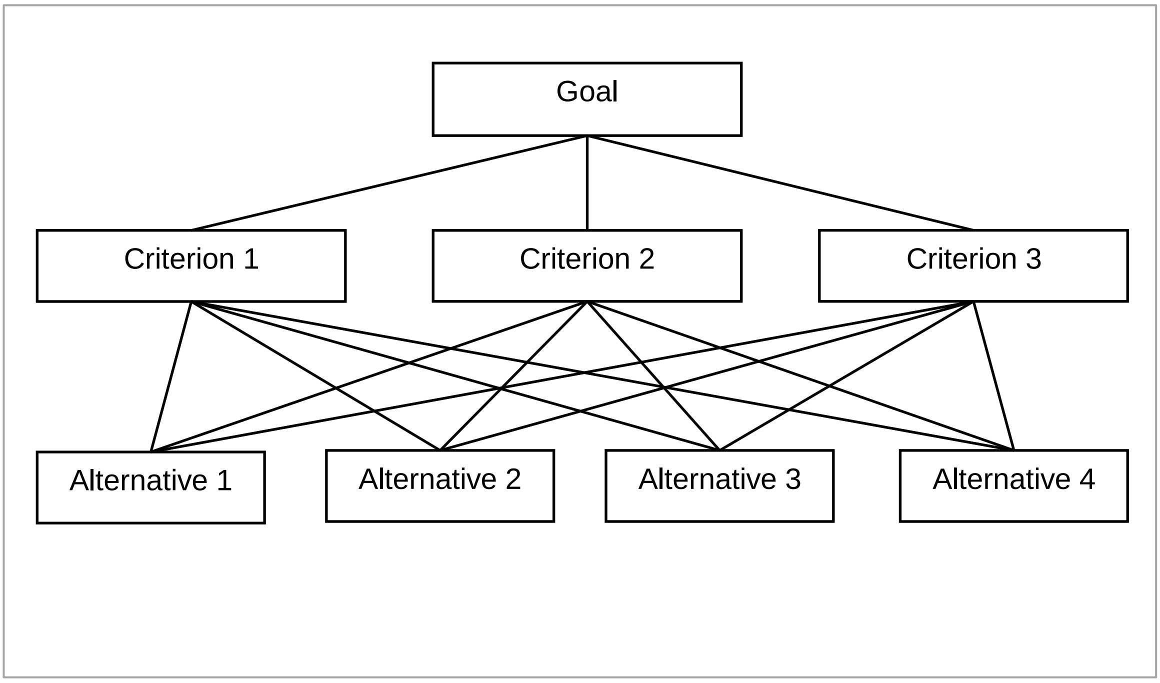


*Figure 14 - Example of a hierarchical model of a problem*

The AHP method can thus provide a more reliable and informative ranking and prioritization of alternatives when compared to using only the RPN value. In addition to prioritizing the alternatives, the method shows their relative importance, that is, how much more important is alternative A when compared to alternative B or C. The method is applicable to different objectives and scenarios as the criteria can be chosen and weighted to accommodate different goals and preferences. While AHP provides many advantages over the RPN ranking method, a major disadvantage of the method is that if too many criteria and alternatives are included in the process, the amount of pairwise comparisons to be made may become cumbersome and the uncertainty of the process is increased significantly (Tsita and Pilavachi, 2012). Therefore, if the amount of alternatives and criteria is large, some preliminary screening may be required to keep the amount of pairwise comparisons manageable.

# 4. METHODOLOGY

Conducting the empirical section of this study is approached through the means of action research. Action research is a research method carried out by a team that encompasses a researcher and the members of an organization who are seeking to improve the participants' situation through joint participation in the research and then taking action that leads to a more favorable situation for the stakeholders (Greenwood & Levin, 2007, 3). Since the focus of the empirical study is one selected service provided by the case company, it is also considered a single case study that aims to produce detailed information of the service in question.

Extant academic literature discussed in the previous sections of this study formed the basis of conducting the empirical study in the case company. The knowledge about the main dimensions of service productivity together with the discussed tools to identify and evaluate improvement opportunities were applied in practice with the aim to provide a plan to improve the case service's productivity. Some existing documents provided by the case company were used, but the majority of data was produced during the empirical research process by the participants and through participant observation.

During the empirical study where the FMEA and AHP methods were employed, the role of the author as a participant was to give the company team instructions on how to apply the methods in practice, to document the answers given by the team, to ask supplementary questions concerning the given answers if deemed necessary and to assist in interpreting the results. The aim of the author was to remain objective regarding the answers given during producing the FMEA sheet and the AHP matrices, that is, no personal opinions or suggestions concerning the service or potential improvement opportunities were given by the author during the process. Finally, once the results were observed and analyzed with the company team, brief unstructured interviews were conducted with the participants to inquire their opinions about the usefulness of the applied methods.

# 5. CASE HARDWARE REPAIR AND MAINTENANCE SERVICE

Having discussed the sub-questions of the thesis in the previous sections, this empirical section aims to integrate the knowledge from the literature review into a practical approach to improve service productivity. Developing and implementing the approach in practice seeks to provide an answer to the main research question of this thesis. The approach is empirically tested on the hardware repair and maintenance service of the case company. First, the case company, the service and the company team involved in the study are described. Then, implementing the FMEA and AHP methods together with their results are discussed. Finally, the views of the team regarding the approach are discussed.

## *5.1 Description of the case company*

The case company is a security solutions provider that offers the installation and maintenance of security systems, such as access control, locking, surveillance and door automation. The company has offices in 19 cities across Finland and employs over 350 staff. Their annual turnover exceeds 55M€ (2018) and their customers range from small private enterprises to public sector customers such as schools, cities and hospitals, and critical infrastructure.

While currently the majority of the company's turnover is comprised of system installation projects, they strive to continuously increase the proportion of services in their sales mix. Competition in the industry has led to increasingly low margins from installation projects, which has incentivized the company to shift its focus towards providing more services for better profitability. Their service portfolio includes hardware repair service, preventive maintenance, system administration and support and customer training among others. Developing new services to meet evolving customer needs is part of the company's strategy.

## *5.2 Service description*

This thesis focuses on the hardware repair and maintenance service of the case company. According to the service description, the purpose of the service is to efficiently produce high-quality maintenance services for the client's security, locking and door automation systems. The objective of the service is to support the undisturbed operation of client systems and prevent system failures. In order to ensure the high quality and efficiency of the service, the service is nationally specified and standardized, but is always produced by the closest regional office.

Service requests related to maintenance services are received via phone or email by customer service and directed to the maintenance experts of the company. The service requests are analyzed, prioritized and resourced in the regional maintenance work management. The client is contacted before starting the maintenance work in order to specify the service request and to provide a more accurate timeframe for the maintenance if possible. A regional maintenance representative carries out the maintenance work in accordance with the service request. The goal is to carry out maintenance work as planned and, in case of malfunctions, during one visit.

The maintenance representatives use service vans for transporting themselves, the necessary equipment and spare parts to customer locations. Service orders are managed in the company ERP system which, according to the company's service personnel, has proven to be somewhat inefficient solution for managing the service process. Maintenance representatives in the field have no easy access to the system and order information which causes issues in the flow of information both internally and towards customers. Further, information required to conduct maintenance work efficiently, such as customer data, contract information and product manuals, is scattered across multiple systems and locations across the company.

## *5.3 Research setting and team description*

For the purpose of conducting the FMEA and AHP analyses, a team of experts was convened that represented different areas of the maintenance service process. The company team consisted of five employees; the company's service manager, one maintenance work manager and three maintenance representatives who specialized in different customers and security systems. The employees' work experience in the case firm ranged from two to eight years. The author was present in the meeting as the sixth member. Excluding the author, only the service manager had prior experience from using the FMEA in another company, and none of the employees had experience from using the AHP method.

Both the FMEA and AHP analyses were conducted at the company's premises in Southern Finland. Due to time constraints of the team involved, the FMEA and AHP analyses were conducted in separate meetings. The FMEA was conducted as a brainstorming- and teamwork session that lasted approximately three hours. The team was given instruction on how to proceed with the FMEA using the process flow chart as a guide. The author documented the answers on the FMEA sheet as they emerged from the brainstorming discussion, and once all process steps were analyzed for potential failure modes, the FMEA sheet was looked over with the company team and necessary clarifications and adjustments were made.

The AHP was then conducted as a teamwork exercise by the same team which lasted approximately two hours, including the analysis of the results with the author. The AHP spreadsheet was prepared by the author who instructed the team on how to fill the matrices. The team made the evaluations collectively through discussion, which were documented again by the author. Once all matrices were filled, the author checked the matrices for consistency and necessary adjustments were then made accordingly. Once all matrices were consistent, the final results were analyzed with the team and conclusions were drawn.

## *5.4 Failure modes and effects analysis*

The process FMEA was employed to identify inefficiencies and improvement opportunities in the hardware repair and maintenance service process. As stated in chapter 3.1, a process FMEA should always be accompanied by a flow chart of the process under analysis. Since the service manager had a previously created process flow chart of the hardware repair and maintenance service that was deemed comprehensive and up to date, it was considered unnecessary to generate a new flow chart for the FMEA and thus the existing chart was used. The process flow chart is illustrated in Figure 15.

The conducted FMEA followed otherwise traditional form, but was extended to include improvement opportunities outside the current process. While the traditional FMEA focuses on actions to prevent or eliminate the most critical failure modes in the existing process, for the purpose of improving service productivity it was seen meaningful to extend the analysis to consider potential alternatives to the existing process, such as technological solutions and automation. Identifying and correcting issues in the current process is likely to yield incremental service productivity improvement through reduced costs and increased customer satisfaction, but ignoring the option to make more radical changes to the process and innovate will likely omit important service productivity improvement potential. Thus, in addition to determining recommended actions for the top failure modes, improvement opportunities were considered especially from a technological perspective. The structure of the used FMEA sheet is shown in Figure 16.

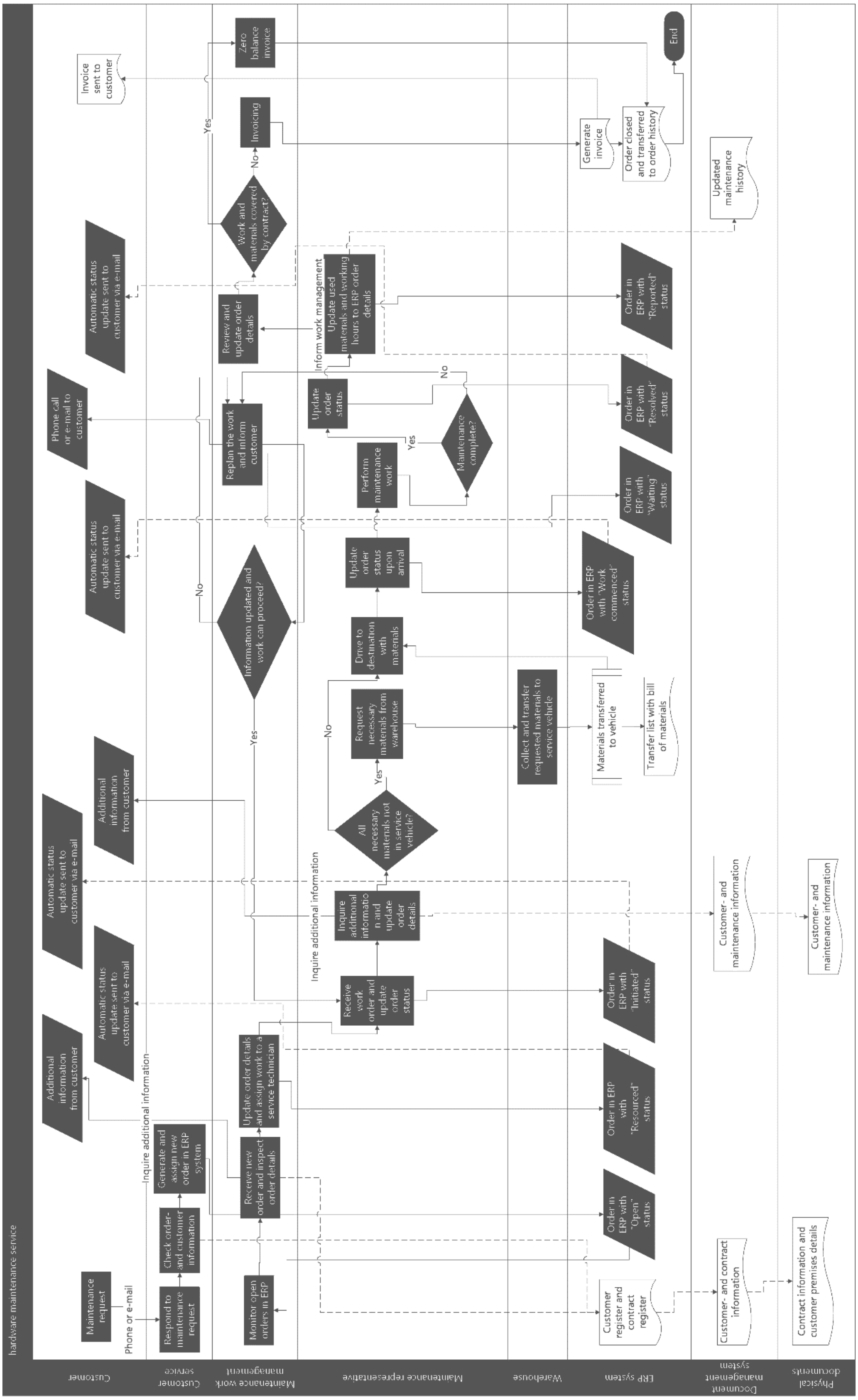


*Figure 15 – Hardware repair and maintenance service process flow chart*

A total of 37 failure modes were identified in the process. For scoring the severity, occurrence and detection values of the failure modes, a scale from 1 to 10 was used with written definitions shown in Appendix 2. Recommended actions and improvement opportunities were then defined for the ten most critical failure modes based on their RPN value. One failure mode was omitted from the top ten as it was currently considered uncontrollable by the organization. The remaining nine most critical failure modes, the recommended actions and improvement opportunities are shown in Figure 16. As many of the failure modes resulted from similar issues, especially related to inadequate systems and technological support in the process, some failure modes shared similar corrective actions and improvement opportunities. The identified corrective actions and improvement opportunities were aggregated into five distinct actions that were related to one or more failure modes. The actions could be divided into two categories based on whether they attempted to make corrections into existing processes and systems or introduce completely new processes and systems to replace existing ones. The five distinct actions shown in Figure 17 were then transferred to the AHP analysis.

Based on the author's observations and the team's own thoughts, the team members were predominantly unanimous of the issues in the process and the identified failure modes. Most failure modes were related to the lack of a system and technology that would provide adequate support for the hardware repair and maintenance service process. The company's current ERP system is outdated and poorly designed for the needs of the maintenance service by modern standards. The overall process involves many manual tasks and very little automation is employed. The amount and nature of manual tasks involved together with the insufficient technological support introduces a variety of failure modes in the current process. The maintenance representatives in the field have no easy access to the systems for performing critical tasks in real time, such as updating the status of service orders or document used materials. This impairs the flow of information both internally and towards customers.

| Process step | Potential failure mode | Failure mode effects | S | Potential causes | O | Current controls | D | RPN | Recommended actions | Improvement opportunities |
|---|---|---|---|---|---|---|---|---|---|---|
| Replanning the job after initial visit and informing the customer | Work management or maintenance representative forgets to inform the customer after initial visit and replanning | Customer is frustrated and loses trust. Maintenance contract terminated by customer | 8 | Manual step that relies on work management's memory. No system automation or checking if customer has been informed | 8 | Cursory review of job backlog in weekly team meetings | 8 | 512 | More thorough review of service order backlog in weekly team meetings | Replace current ERP with one that has better workflow management and -tracking features |
| Update order status upon arrival to customer location | Maintenance representative forgets to send the status update SMS to customer service | Customer is uninformed of the order status, causes frustration | 7 | Manual step that relies on memory, easy to forget | 8 | None | 9 | 504 | Continuously reminding staff to send the SMS | Developing a field service tool where order information can be managed directly |
| Updating the order status to "Complete" after finishing the job | Maintenance representative forgets to update the order status, invoicing of the order is delayed | Issues with working capital and cash flow | 8 | Manual step that relies on memory, easy to forget | 6 | None | 8 | 504 | Continuously reminding staff to make the status updates | Developing a field service tool where order information can be managed |
| Documenting the order information to maintenance history | Not enough information documented to maintenance history | Useful information for future maintenance jobs is lost, hardware warranty information lost | 8 | No process established for documentation, insufficient tools for documenting | 6 | None | 8 | 384 | Modify current systems to support more detailed order information documentation | Replace current ERP with one that has better documentation capabilities and information management features |
| Review customer contract terms and prices for invoicing | Reviewing customer contract terms and prices takes excessive amount of time, invoicing delayed | Issues with working capital and cash flow | 8 | Information is scattered across multiple systems and physical documents | 6 | None | 8 | 384 | Compile all essential documentation for the service into one place | Replace current ERP with one that has better information management features |
| Order is closed and transferred to service order history | Critical information is lost during the transfer due to inadequate ERP system features | Useful information for future maintenance jobs is lost, hardware warranty information lost | 8 | Current ERP system is not designed for the needs of the service process | 6 | None | 8 | 384 | Modify current ERP to enrich service order history data | Replace current ERP with one that has better documentation capabilities and information management features |
| Generate new order in ERP, input basic order information and assign order to closest regional office | Customer service inputs erroneous information | Time spent making additional inquiries from customers, delayed resolution times | 8 | Customer service unable to verify information because information not easily available, customer service is overloaded with work, customer is unable to describe the problem | 9 | None | 5 | 384 | Compile all essential documentation for the service into one place, train customer service personnel | Replace current ERP with one that has better information management features |
| Replanning the job after initial visit and informing the customer | Work management forgets to replan the job | Resolution time delayed, customer frustration and distrust | 8 | Insufficient workflow management, ERP not well designed to support the process | 6 | Cursory review of job backlog in weekly team meetings | 7 | 360 | More thorough review of job backlog in weekly team meetings | Replace current ERP with one that has better workflow management capabilities |
| Update materials and working hours to order in ERP | All used materials and spent hours not inserted correctly | All materials and resources not invoiced, lost profits | 8 | Spent materials and working hours are updated at best case at the end of each work day, sometimes days later. Maintenance representatives rely on their memory when doing the updates | 5 | None | 8 | 336 | Continuously reminding staff to make the updates every day | Develop a field service tool where order information can be managed directly |

*Figure 16 - Top 9 failure modes*

Information required in the process, such as customer contact details, SLAs, warranties and order details, is scattered across multiple systems and shared hard drives, which complicates the whole service process and causes inefficiency. Customer service and service management are often unable to validate contact- and order information because they are unable to locate the relevant documentation, which results in failures such as delays, time-consuming additional inquiries and invoicing errors that incur unnecessary costs and reduce service quality.

Managing the maintenance orders efficiently is challenging because the current systems provide no clear visibility on the overall order backlog. This has made efficient resource allocation difficult and has caused issues in completing maintenance orders on time. Order backlog management is heavily reliant on order status updates made by maintenance representatives on the field, which is done by sending an SMS containing the order number and the new status to the company's customer service who then change the order status in the ERP system. Unfortunately, the maintenance representatives often forget to send the SMS which can impair the workflow and leaves the customer uninformed of the order progress. This was realized to have a significant impact on customer perceived service quality because both delays and lack of information cause discontent and distrust, and ultimately results in lost customers.

Because maintenance representatives have no easy access to the system to manage order information in the field, invoicing the correct items and hours sometimes relies on the representatives' memory when they invoice the order days or weeks after performing the maintenance work. This often results in incorrect invoicing, either not invoicing all the items and labor used which results in lost revenues, or excess invoicing which can antagonize customers and cause distrust if they notice the error. Further, when service orders are invoiced and transferred to order history archive in the current ERP system, some of the service order information gets deleted in the process. Currently the company has no separate process in place for documenting service order history. As a result, the company has limited visibility of customers' order history which could be utilized in daily service management.

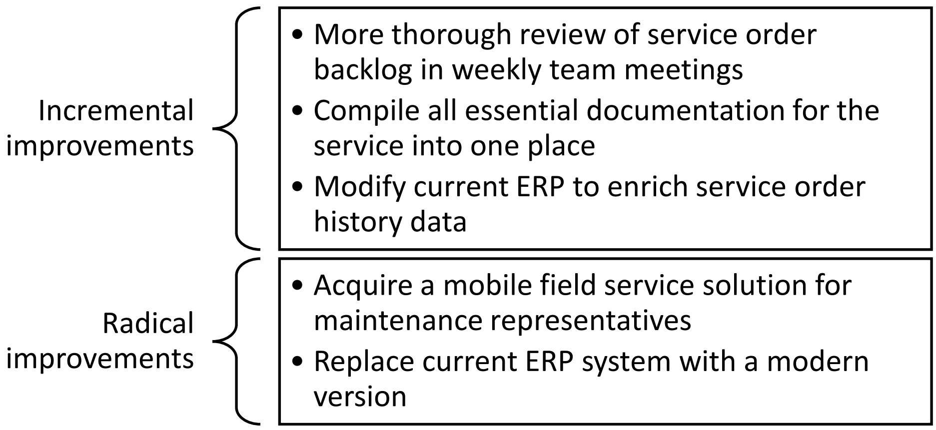


*Figure 17 - Five productivity improvement opportunities*

## *5.5 Analytic hierarchy process*

Having identified the five most critical improvement actions using FMEA, the next step was to prioritize the actions using the analytic hierarchy process. While the selection of the five actions from FMEA was based on the RPN value, the RPN value alone provides little information of their service productivity improvement potential. Previous studies that have combined AHP with FMEA have utilized AHP to extend the criticality analysis of FMEA, using the same RPN criteria of severity, occurrence and detection to evaluate the failure modes (Braglia, 2000; Carmignani, 2009; Hu et al., 2009; Zammori and Gabbrielli, 2012). The method presented here takes a different approach by using criteria derived from service productivity theory as evaluation criteria in the AHP. The purpose of this approach is to assess the service productivity improvement potential and viability of the alternatives instead of simply continuing the criticality analysis of FMEA.

The five improvement actions, serving as the problem alternatives for AHP, were evaluated pair-wise with respect to five criteria. The first four criteria, namely *customer perceived service quality*, *cost-savings*, *work efficiency* and *employee satisfaction*, were derived from the dimensions of service productivity discussed in chapter 2 and considered reasonable proxies for the discussed efficiencies of service productivity. The fifth criterion, *ease of implementation*, was included to evaluate the possibility of implementing the alternatives in practice under cost- and technology constraints and organizational resistance. The AHP hierarchy structure is shown in Figure 18.

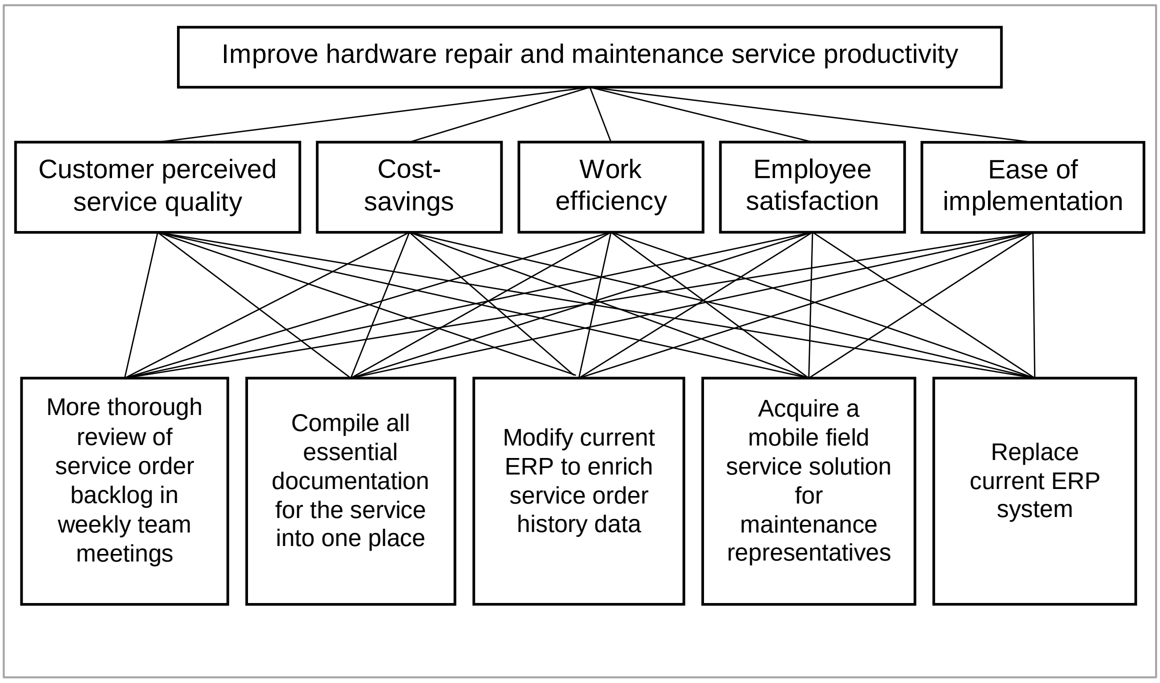


*Figure 18 - The AHP hierarchy structure*

The first criterion, *customer perceived service quality*, represents the quality of the outcome and the delivery process of the service, that is, the *external efficiency* dimension of service productivity. *Cost-savings* represent the *internal efficiency* dimension that comprises the quantity and quality of both provider and customer inputs required to produce the service, such as time, personnel and equipment. *Work efficiency* reflects the *capacity efficiency* dimension, assuming that the more efficiently employees are able to perform their tasks with available tools and technology, the better the company is able to meet demand with less workforce. Employee satisfaction represents the *meaning efficiency* of service productivity, assuming that satisfied employees are more motivated and therefore more productive.

The pair-wise matrices and the required calculations were constructed in MS Excel by the author. The company team was instructed to score the matrices using Saaty's fundamental scale shown in Appendix 1. Once all matrices were filled by the team, the matrices were reviewed for consistency by calculating the consistency ratio (CR). A threshold of CR <= 0,1 was used as suggested by Saaty (1987). All matrices with CR > 0,1 after the initial scoring were revised and adjusted until consistency was below threshold. The criteria weights and priorities for alternatives were then calculated for each matrix using the eigenvalue method. See Saaty (1987) for the fundamental calculation procedures of AHP. The evaluations of the pair-wise matrices with their calculated priority scores and consistency ratios are shown in Figures 19-24, and the derived final evaluation of alternatives is shown in Figure 25. The filled matrices are shown in Appendix 3.

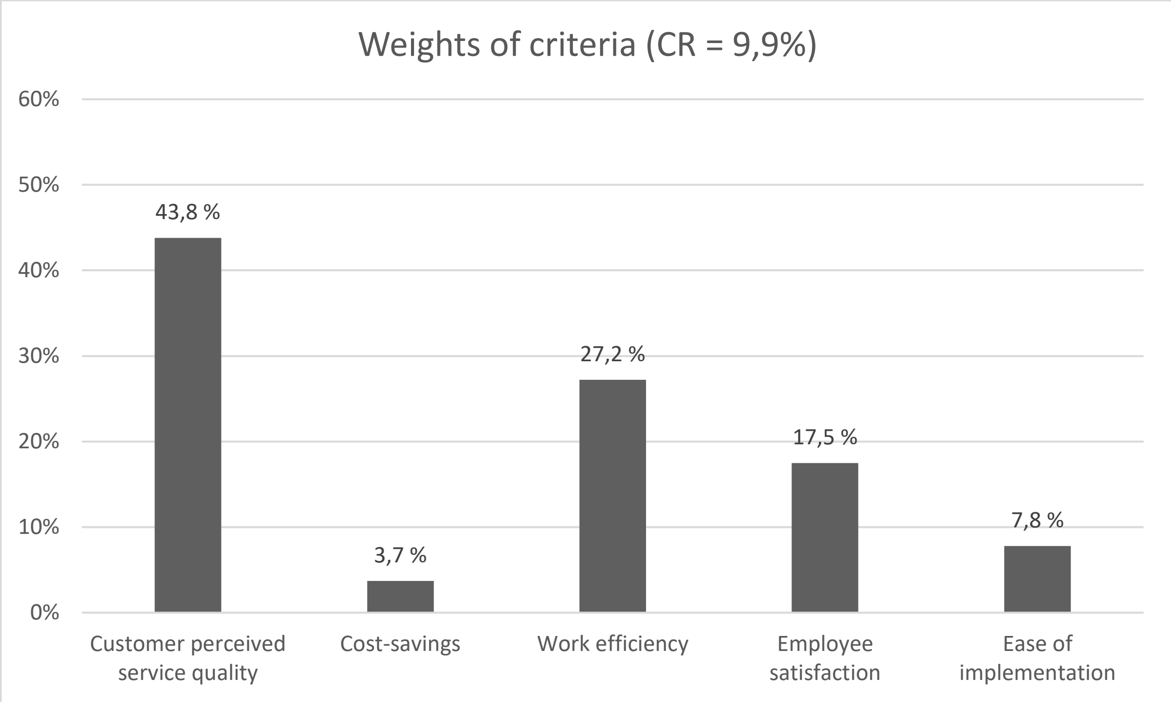


*Figure 19 - Weights of criteria*

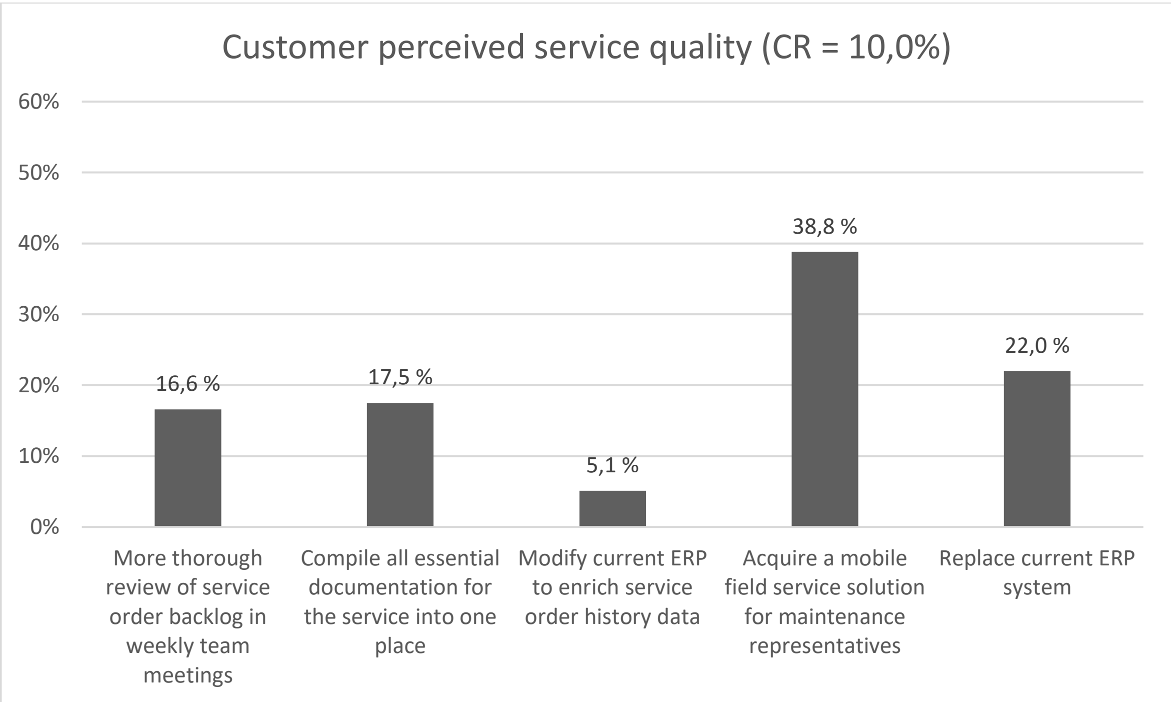


*Figure 20 - Customer perceived service quality*

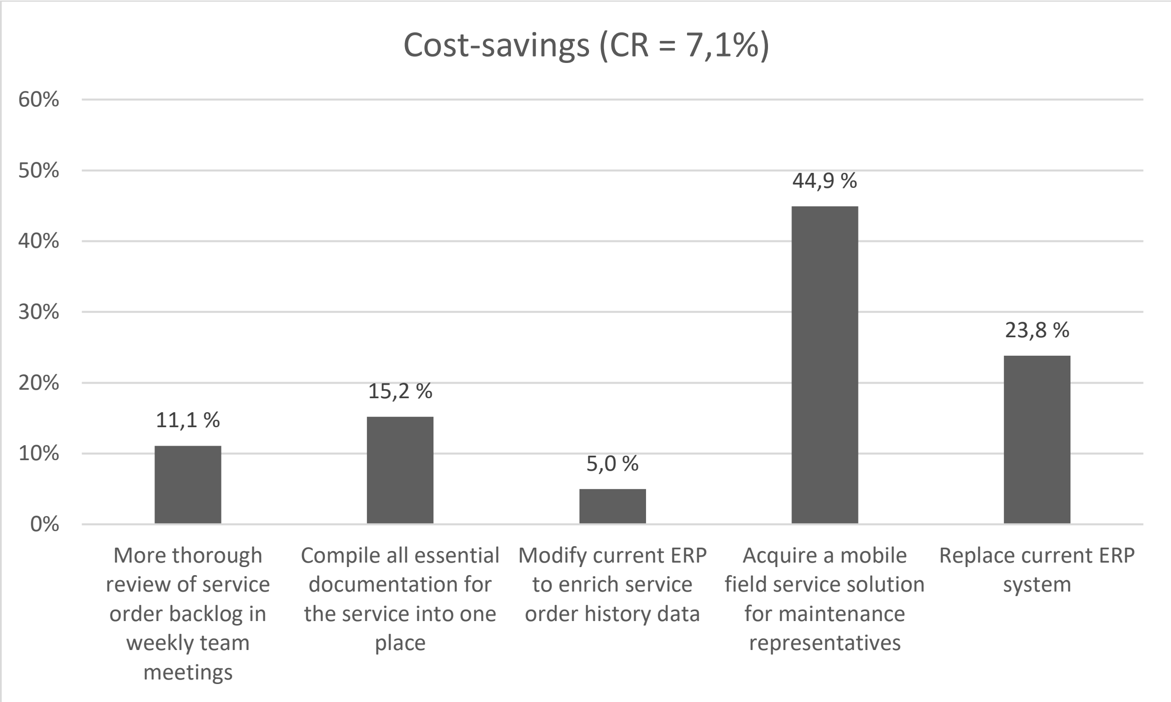


*Figure 21 - Cost-savings*

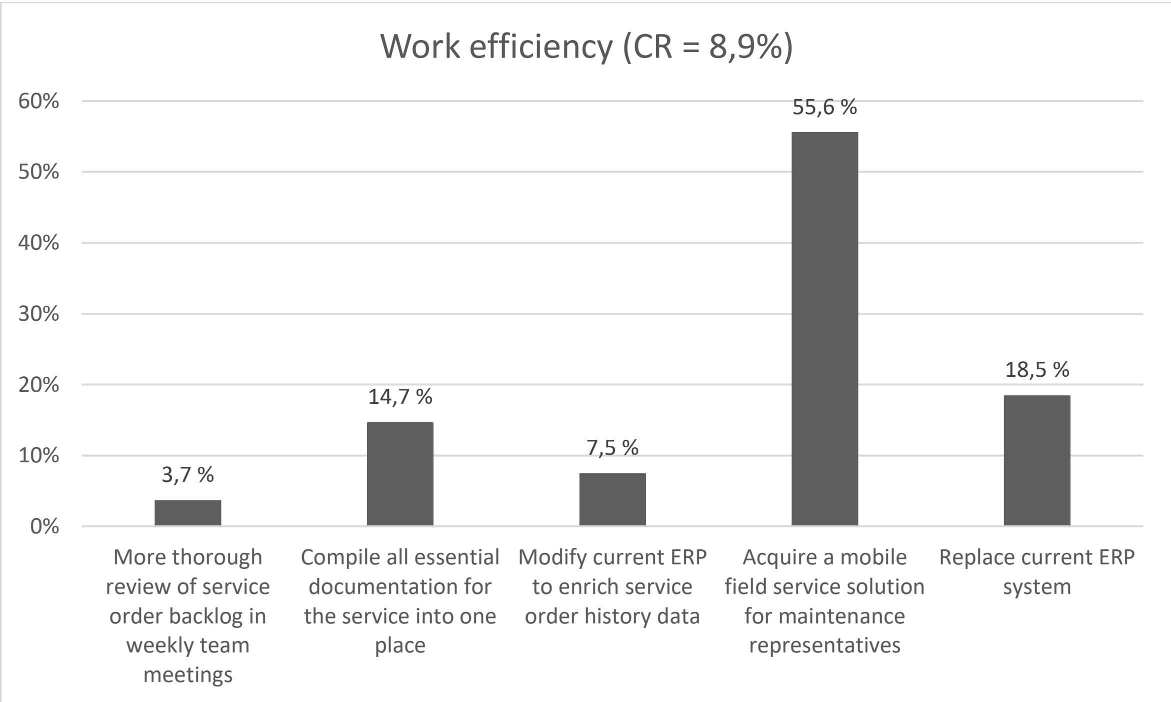


*Figure 22 - Work efficiency*

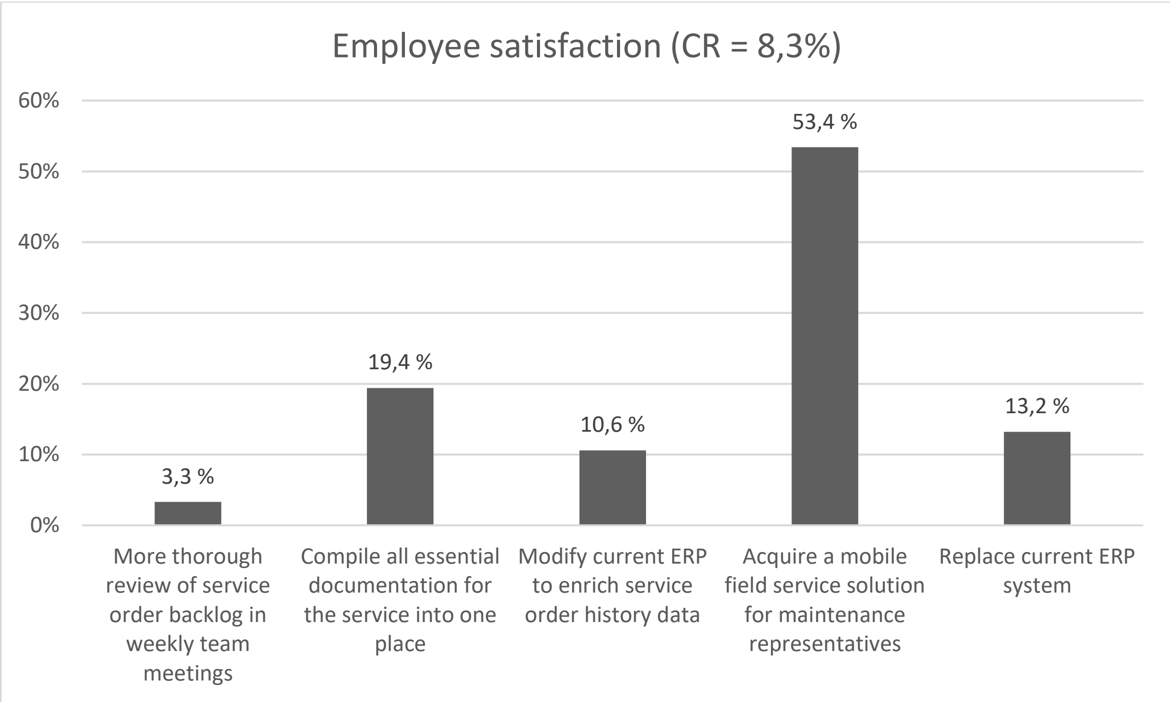


*Figure 23 - Employee satisfaction*

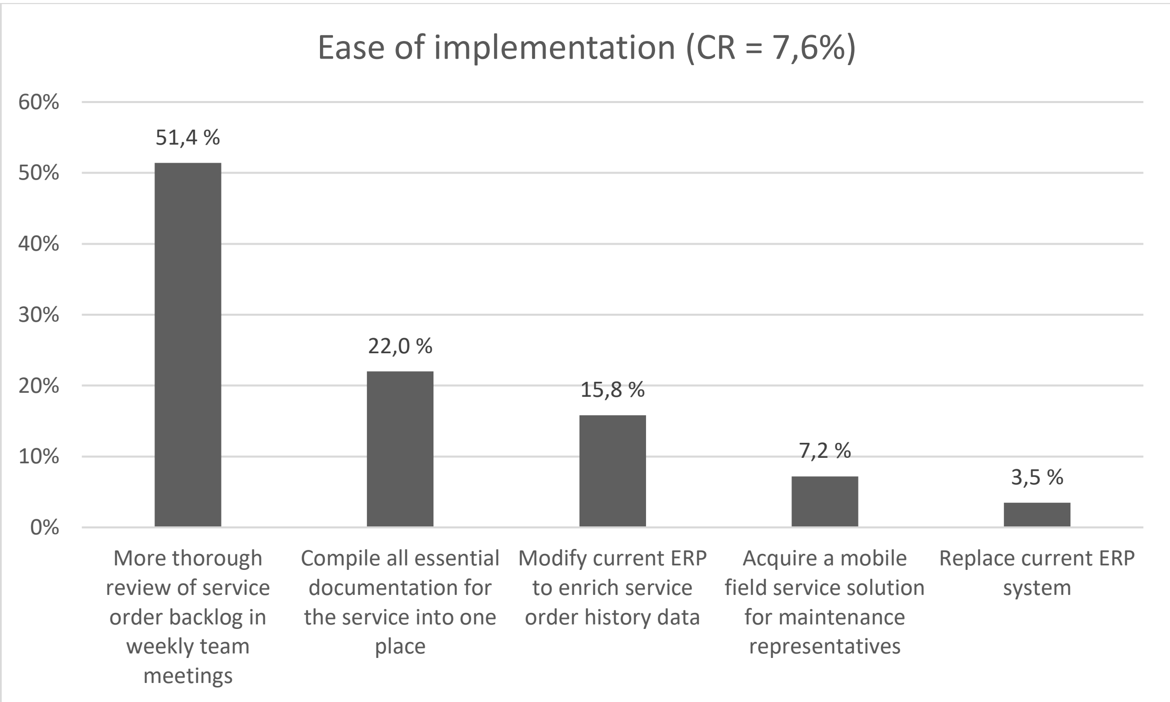


*Figure 24 - Ease of implementation*

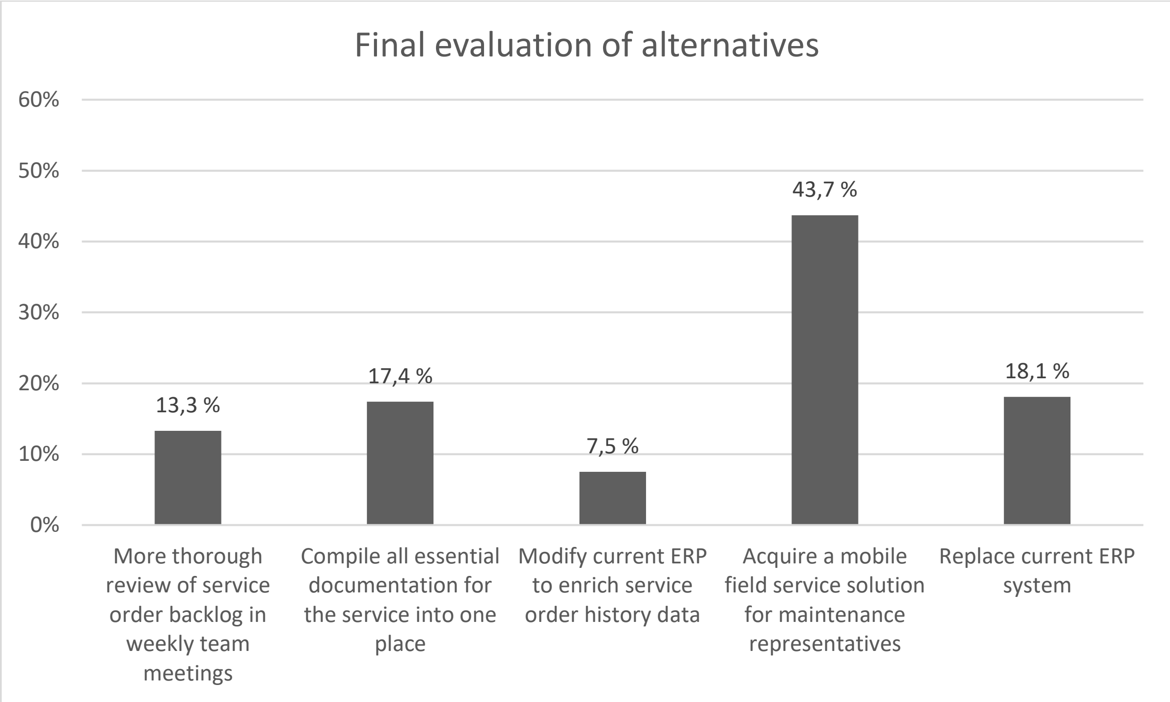


*Figure 25 - Final evaluation of alternatives*

## 5.6 Results and discussion

In this section, the results of the AHP are first discussed in detail and then the overall results are discussed concerning the state of the service in light of the service productivity concept. The weights of criteria are first analyzed and then the final prioritization of alternatives is examined.

### 5.6.1 Weights of criteria

Of the five criteria included in the analysis, the team considered *cost-savings* the least important for improving the productivity of the repair maintenance service with a relative weight of only 3,7%. According to the team, cost reductions are not a priority because cost and price issues are currently not relevant for the success of the service. The service manager stated that their customers are mainly concerned about service quality:

> *"The cost structure and price are not the issue. The negative customer feedback we receive about our service, especially what we hear through our sales department, is about poor service quality instead of high price."*

Therefore, focusing on internal efficiency, which in the traditional view to productivity is often considered the main source of productivity, was considered the least important in this case. This is a reasonable result because as discussed in chapter 2.3, productivity and service quality are often in conflict, especially when productivity is viewed from the traditional manufacturing perspective where internal efficiency is emphasized. Because the team acknowledges that the level of customer perceived service quality is currently inadequate, cost-savings are given very little weight. Customer perceived service quality, work efficiency and employee satisfaction were all considered to have very strong importance over cost-savings with respect to the goal.

The fifth criterion, *ease of implementation*, also received a relatively small weight of 7,8%. This result was explained by the team's awareness of the amount and seriousness of problems in the service process that are not easily resolved. The team members expressed their willingness to adopt change because the current process and the systems involved make their work inconvenient. Replacing the outdated ERP system and adopting new technology are laborious projects, but due to the current situation and acknowledging the potential in modern solutions, the team's threshold to adopt substantial change has been lowered.

*Employee satisfaction* was ranked third with a weight of 17,5%. In their discussion, the team reasoned that employee satisfaction has a moderate effect on service productivity, but mainly through increasing work efficiency and customer perceived service quality. However, the maintenance representatives also discussed that their satisfaction may not have a significant effect on their work efficiency:

> *"In the end we just come here to do our job, and our satisfaction does not make a big difference on how efficiently we do it. We do what we are told and work according to the norms."*

This result indicates that there might not be any significant problems in employee satisfaction. Despite the somewhat pessimistic notion made by the maintenance representatives, the team recognized employee satisfaction as an important factor for service productivity and ranked it more significant than cost-savings and ease of implementation. As discussed in chapter 2.4, leveraging on human resources through motivation should become more of a priority when technical efficiency is achieved. It is evident that in this case, the service has not achieved technical efficiency due to outdated systems and other process-related issues identified with the FMEA. Therefore, this weight value of employee satisfaction seems reasonable in this situation.

*Work efficiency* received the second largest weight value of 27,2%. As the FMEA results indicated, work efficiency is currently impaired by the lack of adequate tools and technology, which results in failures that further deteriorate service quality. The team recognized many issues concerning work efficiency in the process, both in the maintenance representatives' field work and the service management's process. The team was also aware of the potential that modern technological solutions can provide in terms of efficiency gains, such as some workflow management systems and handheld field service solutions. Thus, work efficiency was given a relatively strong weight by the team.

Overwhelmingly strongest weight was given for *customer perceived service quality* with a weight of 43,8%. This reflects the known issues in the process that impair service quality but also the customer orientation of the team. The team acknowledged that pursuing growth in their service business is futile if they cannot provide their customers with a service that is considered high quality. As mentioned earlier, quality issues have already resulted in negative customer feedback and lost customers, which can lead to bad word-of-mouth and damaged reputation. The main priority of the team is evidently to keep their customers happy by providing high quality service, but the lack of adequate tools and technology has made it difficult for the team to maintain high service quality for all customers.

Overall, the weights of criteria indicate that the productivity of the hardware repair and maintenance service is mainly impaired by problems in customer perceived service quality and work efficiency. It can be postulated from the FMEA results and the team's discussion that the technological constraints form the major impediment for better work efficiency and service quality. Lower work efficiency results in longer waiting times for customers, reducing perceived service quality, and the technological constraints further impair the functional quality of the service when, for example, customers are left uninformed of their maintenance request's status. Acknowledging that implementing the required improvements in technology requires significant effort, ease of implementation was not given much weight.

### *5.6.2 Order of alternatives*

*Modify current ERP system to enrich service order history data* was prioritized as the least important action with a relative evaluation of 7,5%. Implementing this action would have provided maintenance representatives and managers more information on customers' maintenance history, which could be useful information for future service calls. This action was considered to have very little impact on customer perceived service quality (5,1%), cost savings (5,0%) and work efficiency (7,5%) in relation to the other alternatives. Further, modifying the current ERP system would require using external IT consultants which increases the implementation costs, together with the fact that the current ERP system is considered outdated and spending more time and money on patching it was not considered wise by the team. Thus, it was ranked as the least important of the five alternatives.

*Reviewing the service order backlog more thoroughly in weekly team meetings* was ranked fourth with a relative evaluation of 13,3%. The purpose of this action was to make sure that service orders are finished on time and that customers are kept informed on their service order's status by manually going through the order backlog in the ERP system on a regular basis. This was considered to have a positive effect on customer perceived service quality by making sure maintenance representatives do not forget to carry out unfinished jobs and make the necessary status updates, especially when they are unable to finish the job during the first visit. However, the team noted unanimously that having everyone spend more time in internal meetings is not beneficial for work efficiency or employee satisfaction. Time spent in internal meetings is away from serving their customers and while this action would benefit customer perceived service quality, it would only be treating the symptoms of the real problem caused by inadequate tools and lack of technological support in the process. It was considered the easiest to implement by a wide margin (51,4%) as the team can simply make the decision to reserve more time for the meetings in the future. Yet, due to its adverse effects on work efficiency and employee satisfaction, in the overall evaluation it was only ranked fourth.

*Compiling all essential documentation for the service into one place* received a relative evaluation of 17,4%, ranking it third. This action was considered to have a noticeable positive effect on all service productivity dimensions, while also being the second easiest to implement of the five alternatives. Having all the required information organized and accessible through one channel would improve work efficiency throughout the service process. Erroneous invoicing caused by missing contract- or warranty details would be mitigated, and the ability to validate order- and contact information upon receiving the order would be improved, which would reduce time spent calling customers for additional information and consequential delays. Thus, both work efficiency and customer perceived service quality would be improved, and employee satisfaction would be improved by reducing frustration caused by the difficulty to find required customer- and order information.

Next, *replacing the current ERP system* was evaluated slightly higher with a relative evaluation of 18,1%, ranking it second. This alternative was considered more important in terms of customer perceived service quality (22,0%) and work efficiency (23,8%) than all the previous alternatives, but concurrently it was seen as the most difficult to implement (3,5%). Again, many of the identified failure modes were related to issues caused by the outdated and somewhat inadequate ERP system currently in use, which according to the team should have been replaced a long time ago.

Assuming that a modern replacement would be implemented successfully, many of the identified problems affecting all the service productivity dimensions would be solved. Further, it is reasonable to assume that modern systems can provide better efficiency in areas such as workflow management, information management and invoicing. Thus, replacing the outdated ERP system could not only correct many of the identified failure modes but also further increase the level of efficiency by streamlining the overall process. However, ERP projects are notoriously challenging and stressful ventures, which is reflected in the *ease of implementation* -scoring. Despite the difficulty of implementation, the team acknowledged the substantial potential in modern systems that would improve all service productivity dimensions. Therefore, this alternative was ranked as the second most important.

Finally, unequivocally the most important alternative was considered to be the *mobile field service solution for maintenance representatives* with a relative evaluation of 43,7%, making it over two times more important than the second priority alternative. This alternative received the highest evaluation in customer perceived service quality (38,8%), cost-savings (44,9%), work efficiency (55,6%) and employee satisfaction (53,4%), and was considered the second-most difficult to implement (7,2%). The team sees remarkable potential in this alternative in terms of making the maintenance representatives' daily work more efficient and enjoyable, the benefits of which would be reflected on better customer perceived service quality and cost efficiency.

Allowing the maintenance representatives to update order statuses and document materials and time spent on maintenance jobs in real time through a handheld device would solve many of the failure modes concerning the flow of information both internally and towards customers, material handling and invoicing. Maintenance representatives could abandon the current procedure of spending a significant portion of their work day on a computer making the necessary documentation, usually at the end of the day having to rely on their memory. Instead, managing the information during the maintenance job would arguably require less time and leave less room for error, improving work efficiency and customer perceived service quality by keeping customers up to date on their maintenance orders' status.

The team was knowledgeable about such technological solutions already popular in other industries' repair and maintenance services, such as the elevator industry. Academic literature also supports the service productivity potential in such technologies (see chapter 2.5.1) and implementing technological solutions that are visible to customers have been known to further improve the company's image when customers view the company as a high-tech service provider (Kowalkowski, 2008). Thus, in light of this analysis, the mobile field service solution would clearly provide the greatest potential for improving the service productivity of the hardware repair and maintenance service.

### *5.6.3 Discussion*

The results of the FMEA together with the AHP evaluations suggest that for the hardware repair and maintenance service of the case company, technology forms the largest obstacle for service productivity, but also offers the greatest improvement potential. The company's business and the industry have evolved substantially during the last decade towards servitization, but the technological resources of the company have not followed suit. As discussed in section 2.5.1, the optimal level of productivity is a moving target because technology advances over time, forcing managers to re-evaluate their technology periodically to optimize service productivity. In recent years, the case company has not made any substantial investments in new technology that would benefit the service process, which has led to the present situation. Incremental modifications and patching have been applied to the current ERP system, but it has become increasingly evident that modern alternatives would serve the company's needs much more efficiently.

Upgrading the ERP system and investing in a mobile field service tool for maintenance representatives' use would require significant effort, but the resulting benefits would likely outweigh the required effort by a wide margin. Comparing the evaluation of these two more radical alternatives with the others that were focused on lesser changes and modifications to extant processes, it is quite evident that more substantial change is justified. This result highlights the importance of also considering more radical improvement- and innovation opportunities when using the FMEA or similar tools for the purpose of identifying productivity improvement opportunities. Constant productivity improvement through incremental innovation is important to maintain competitive advantage, but sometimes the greatest improvement potential lies in more radical solutions.

Having analyzed the results with the company team, the consensus among the team was that the results depicted the current state of the service and its issues accurately, and highlighted the acute need to bring their technology up to date. The team was also pleased with the applied methods, as they brought new perspective to the issues and solutions concerning the maintenance service process and elicited meaningful discussion. Overall, for the purpose of identifying and evaluating service productivity improvement opportunities, the method was deemed viable and thus provides an answer to the second sub-question of this thesis.

# 6. CONCLUSIONS

The main purpose of this thesis was to study how service productivity can be improved. In order to systematically answer this question, it was first studied what productivity means when the term is applied to services. The dimensions of service productivity were studied in the literature review section, where four main dimensions that affect service productivity were identified, namely *internal efficiency, external efficiency, capacity efficiency* and *meaning efficiency*. The findings from literature underlined the differences between the concepts of traditional manufacturing-based productivity and service productivity, resulting from the inherent characteristics of services and service consumption that diverge from the manufacturing and consumption of physical goods. In services, productivity should not be considered a variable to be maximized, but a strategic decision variable to be optimized for maximum profitability, the optimal level of which depends on the relative importance of customer satisfaction and the level of technology.

Then, to answer the second sub-question, two systematic techniques were selected and used in conjunction for the purpose of identifying and evaluating service productivity improvement opportunities. The failure modes and effects analysis (FMEA) was used to identify improvement opportunities, and the analytic hierarchy process (AHP) was used for evaluating and prioritizing the identified improvement opportunities. The four identified dimensions of service productivity were integrated to the evaluation phase of the method to focus on specifically evaluating improvement potential in service productivity. The produced approach was then applied to the hardware repair and maintenance service of a Finnish security solutions provider. The results of the empirical study suggest that the method can be effective in identifying improvement opportunities through systematically analyzing the whole service process, and then prioritizing them based on their effect on the service productivity dimensions. The method allows weighing the relative importance of the productivity dimensions, making it more applicable to varied services, markets and industries. The chosen approach is obviously not the only possible method for identifying and evaluating service productivity improvement opportunities, but it was deemed viable for the purpose.

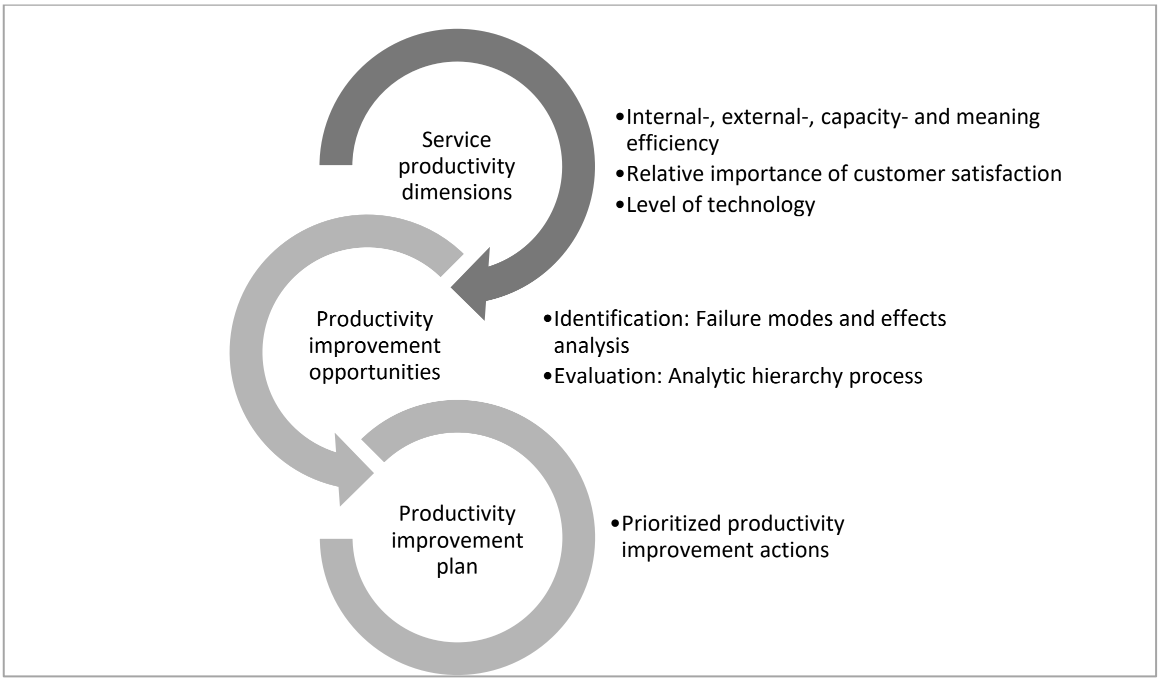


*Figure 26 - The final framework of the thesis*

## 6.1 Managerial implications

Understanding the dimensions and dynamics of service productivity in contrast to the traditional manufacturing-based view to productivity is essential when productivity is managed in services. The characteristics of services and service consumption that lead to the interrelationship between productivity and service quality must be understood to avoid damaging profitability due to the potential trade-off effects. Although service customers buy outcomes, their evaluation of the service quality is largely based on the quality of the service process in addition to the quality of the outcome. Because customers perceive the quality of the service process, changes made to the company inputs’ quality and quantity impact customer perceived quality and consequently the revenue-generating capability of the service. Thus, while traditional productivity improvement methods focusing on cost-cutting and maximizing automation might yield noticeable short-term productivity gains in services, the resulting damage to customer perceived service quality may eventually lead to excessive customer attrition and decreased profitability.

The systematic method of identifying and evaluating service productivity improvement opportunities introduced in this thesis provides managers a viable approach to improve the productivity of their service. Using the FMEA and AHP methods is not limited to any specific type of service, market or industry, which makes the approach widely applicable to many situations. The FMEA and AHP can be conducted using typical spreadsheet software, although building the AHP logic and calculations requires some fundamental knowledge of the AHP. Alternatively, purpose-made software solutions are available for conducting both methods.

## *6.2 Theoretical implications*

This thesis aimed at first reviewing the existing theory of service productivity and then applying it to practice through using systematic decision-making techniques. The four main dimensions of service productivity identified in the literature review were used in the practical approach as evaluation criteria, against which the identified productivity improvement opportunity alternatives were weighed. Previous studied that have combined FMEA with AHP have focused on utilizing AHP to extend the criticality analysis and RPN calculation of FMEA. The method presented in this thesis provides a new approach to using AHP in conjunction with FMEA by employing evaluation criteria that relate to factors other than the FMEA criticality assessment, in this case the service productivity improvement potential of the actions derived from FMEA.

The empirical results suggest that the developed approach is feasible in identifying service productivity improvement opportunities and then evaluating and prioritizing them based on their expected impact on service productivity and feasibility. However, it is not concluded that the practical approach developed and tested in this thesis is the only viable approach to identify and evaluate productivity improvement opportunities in services. Although this thesis did not aim to extend the theory of service productivity itself, the review and discussion of extant theory and its application into practice can serve as a basis for future studies aiming to develop similar approaches.

## *6.3 Limitations and suggestions for future research*

This study was limited to identifying and evaluating service productivity improvement opportunities prior to implementation. Obviously, productivity improvements are not gained without taking action and the true productivity improvements of the identified opportunities remain unknown until they have been implemented and measured. The evaluation of criteria and alternatives in this study were ultimately based on subjective views of the team members. A meaningful continuation of this study would then be to include the implementation and measurement of the identified improvement actions to see how well the realized service productivity improvements reflect the initial analysis. Also, modifying or extending the method to include quantitative data, such as measures for customer perceived service quality, work efficiency and employee satisfaction, to support the evaluation and decision making process could improve the reliability of the method.

Although the selected company team was representative of the internal process of the analyzed service, apart from previous customer feedback, actual customers and their opinions were excluded from the analysis. It is evident that including customers in both the FMEA and AHP could provide critical insight into problem areas and improvement ideas that the service provider is unaware of. Typically, the overall quality of a service cannot be evaluated until it is consumed and experienced by the customer who ultimately evaluates its quality. Therefore, the service provider is typically unable to observe the overall quality of the service internally, which raises the need to include the customer perspective when identifying and evaluating productivity improvement opportunities. It is thereby suggested that the method is extended to also include the customer perspective by involving customers in the FMEA and AHP analyses.

Further, in terms of reliability, the results of both the FMEA and AHP methods are likely dependent on the team conducting the analyses. The subjective views of the selected participants ultimately dictate the results, thus it is important to carefully select the appropriate sample for the method. Conducting the same analyses with a different team setup would likely have resulted in more or less different results. Also, the method of combining FMEA and AHP is not the only possible solution for identifying and evaluating productivity improvement opportunities. The traditional FMEA is mainly focused on issues in existing processes while not paying much attention to broader opportunities such as business model innovations as a means for improving service productivity. Other methods, such as business model canvassing, could be used for identifying improvement opportunities outside the narrow focus of FMEA, while different ranking and prioritizing methods discussed in section 3.2 could provide different results.

The four criteria used in the AHP to proxy the service productivity efficiencies also might not be the most suitable and certainly not the only possible ones for the purpose. Defining the productivity evaluation criteria might require some further discussion, and it is postulated by the author that the “correctness” of evaluation criteria might be somewhat case dependent. Thus, it is suggested that the evaluation criteria for service productivity improvement opportunities could be studied in more detail.

# LIST OF REFERENCES


Anderson, E. W., Fornell, C. & Rust, R. T. 1997. Customer Satisfaction, Productivity, and Profitability: Differences Between Goods and Services. *Marketing Science*, vol. 16, iss. 2, pp. 129-145.

Bian, X. & Zhang, J. 2007. Nine Doctrines of Service Productivity. *2007 International Conference on Service Systems and Service Management*, June 9-11, Chengdu, China.

Braglia, M. 2000. MAFMA: Multi-attribute failure mode analysis. *International Journal of Quality & Reliability Management*, vol. 17, iss. 9, pp. 1017-1033.

Brun, A. & Savino, M. M. 2018. Assessing risk through composite FMEA with pairwise matrix and Markov chains*. International Journal of Quality & Reliability Management*, vol. 35, iss. 9, pp. 1709-1733.

Calabrese, A. 2012. Service productivity and service quality: A necessary trade-off? *International Journal of Production Economics*, vol. 135, iss. 2, pp. 800-812.

Calabrese, A. & Spadoni, A. 2013. Quality versus productivity in service production systems: An organisational analysis. *International Journal of Production Research*, vol. 51, iss. 22, pp. 6594-6606.

Carlborg, P., Kindström, D. & Kowalkowski, C. 2013. A lean approach for service productivity improvements: Synergy or oxymoron? *Managing Service Quality: An International Journal*, vol. 23, iss. 4, pp. 291-304.

Carmignani, G. 2009. An integrated structural framework to cost-based FMECA: The priority-cost FMECA. *Reliability Engineering and System Safety*, vol. 94, iss. 4, pp. 861-871.

Chuang, P. 2007. Combining Service Blueprint and FMEA for Service Design. *The Service Industries Journal*, vol. 27, iss. 2, pp. 91-104.

Ennew, C. T. & Binks, M. R. 1996. The Impact of Service Quality and Service Characteristics on Customer Retention: Small Businesses and their Banks in the UK. *British Journal of Management*, vol. 7, iss. 3, pp. 219-230.

Filiatrault, P., Harvey, J. & Chebat, J. 1996. Service quality and service productivity management practices. *Industrial Marketing Management*, vol. 25, iss. 3, pp. 243-255.

Geum, Y., Cho, Y. & Park, Y. 2011. A systematic approach for diagnosing service failure: Service-specific FMEA and grey relational analysis approach. *Mathematical and Computer Modelling*, vol. 54, iss. 11, pp. 3126-3142.

Geum, Y., Shin, J. & Park, Y. 2011. FMEA-based portfolio approach to service productivity improvement. *The Service Industries Journal*, vol. 31, iss. 11, pp. 1825-1847.

Gilchrist, W. 1993. Modelling Failure Modes and Effects Analysis. *International Journal of Quality & Reliability Management*, vol. 10, iss. 5.

Greenwood, D. J. & Levin, M. 2007. Introduction to action research: Social research for social change. 2nd ed. Thousand Oaks, [Calif.] ; London: SAGE.

Grönroos, C. 1984. A Service Quality Model and its Marketing Implications. *European Journal of Marketing*, vol. 18, iss. 4, pp. 36-44.

Grönroos, C. 1998. Marketing services: The case of a missing product. *Journal of Business & Industrial Marketing*, vol. 13, iss. 4/5, pp. 322-338.

Grönroos, C. & Ojasalo, K. 2004. Service productivity: Towards a conceptualization of the transformation of inputs into economic results in services. *Journal of Business Research*, vol. 57, iss. 4, pp. 414-423.

Grönroos, C. & Ojasalo, K. 2015. Service productivity as mutual learning. *International Journal of Quality and Service Sciences*, vol. 7, iss. 2/3, pp. 296-311.

Gupta, A. 1995. Productivity measurement in service operations: A case study from the health-care environment. *Managing Service Quality: An International Journal*, vol. 5, iss. 5, pp. 31-35.

Ho, W., Dey, P. K. & Higson, H. E. 2006. Multiple Criteria Decision-Making Techniques in Higher Education. *International Journal of Educational Management*, vol. 20, iss. 5, pp. 319-337.

Hu, A. H., Hsu, C., Kuo, T. & Wu, W. 2009. Risk evaluation of green components to hazardous substance using FMEA and FAHP. *Expert Systems with Applications*, vol. 36, iss. 3, pp. 7142-7147.

Huang, M. & Rust, R. T. 2014. Should your business be less productive? *MIT Sloan Management Review*, vol. 55, iss. 3, pp. 67-72.

Johnston, R. & Jones, P. 2004. Service productivity: Towards understanding the relationship between operational and customer productivity. *International Journal of Productivity and Performance Management*, vol. 53, iss. 3/4, pp. 201-213.

Kowalkowski, C. 2008. Service productivity gains through information and communication technology applications: A service marketing approach. *International Journal of Knowledge Management Studies*, vol. 2, iss. 1, pp. 96-114.

Lee, J., Patterson, P. & Ngo, L. 2017. In pursuit of service productivity and customer satisfaction: The role of resources. *European Journal of Marketing*, vol. 51, iss. 11/12, pp. 1836-1855.

Liu, H., Liu, L. & Liu, N. 2013. Risk evaluation approaches in failure mode and effects analysis: A literature review. *Expert Systems With Applications*, vol. 40, iss. 2, pp. 828-838.

Mark, J. A. 1982. Measuring Productivity in Service Industries. *Monthly Labor Review*, vol. 105, iss. 6, pp. 3-8.

McCain, C. 2006. Using an FMEA in a service setting. *Quality Progress*, vol. 39, iss. 9, pp. 24-29.

Nachum, L. 1999. Measurement of productivity of professional services. *International Journal of Operations & Production Management*, vol. 19, iss. 9, pp. 922-950.

Ojasalo, K. 1999. Conceptualizing productivity in services. Helsinki: Svenska handelshögskolan.

Ojasalo, K. 2003. Customer influence on service productivity. *S.A.M. Advanced Management Journal*, vol. 68, iss. 3, pp. 14-19.

Parasuraman, A. 2010. Service productivity, quality and innovation: Implications for service-design practice and research. *International Journal of Quality and Service Sciences*, vol. 2, iss. 3, pp. 277-286.

Rust, R. T. & Huang, M. 2012. Optimizing Service Productivity. *Journal of Marketing*, vol. 76, iss. 2, pp. 47-66.

Saaty, R. 1987. The analytic hierarchy process—what it is and how it is used. *Mathematical Modelling*, vol. 9, iss. 3, pp. 161-176.

Sekhon, H., Yalley, A., Roy, S. & Shergill, G. 2016. A cross-country study of service productivity. *The Service Industries Journal*, vol. 36, iss. 5-6, pp. 223-238.

Teng, S. & Ho, S. 1996. Failure mode and effects analysis. *International Journal of Quality & Reliability Management*, vol. 13, iss. 5, pp. 8-26.

Teoh, P. & Case, K. 2005. An evaluation of failure modes and effects analysis generation method for conceptual design. *International Journal of Computer Integrated Manufacturing*, vol. 18, iss. 4, pp. 279-293.

Tsita, K. G. & Pilavachi, P. A. 2012. Evaluation of alternative fuels for the Greek road transport sector using the analytic hierarchy process. *Energy Policy*, vol. 48, pp. 677-686.

Vargo, S. & Lusch, R. 2004. Evolving to a New Dominant Logic for Marketing. *Journal of Marketing*, vol. 68, iss. 1, pp. 1-17.

Viitamo, E. 2009. On Service Productivity - Strategic Management Perspectives. Lappeenranta: Lappeenranta University of Technology. Research report 205.

Yalley, A. A. & Sekhon, H. S. 2014. Service production process: Implications for service productivity. *International Journal of Productivity and Performance Management*, vol. 63, iss. 8, pp. 1012-1030.

Zammori, F. & Gabbrielli, R. 2012. ANP/RPN: A multi criteria evaluation of the risk priority number. *Quality and Reliability Engineering International*, vol. 28, iss. 1, pp. 85-104.

# APPENDICES

## APPENDIX 1 - Saaty's fundamental scale of preference intensity

| *Intensity of importance* | *Definition* | *Explanation* |
|---|---|---|
| *1* | Equal importance | Two activities contribute equally to the objective |
| *3* | Moderate importance of one over another | Experience and judgement favor one activity over another |
| *5* | Essential or strong importance | Experience and judgement strongly favor one activity over another |
| *7* | Very strong importance | An activity is strongly favored and its dominance demonstrated in practice |
| *9* | Extreme importance | The evidence favoring one activity over another is of the highest possible order of affirmation |
| *2,4,6,8* | Intermediate values between two adjacent judgements | When compromise is needed |
| *Reciprocals* | If activity *i* has one of the above numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared with *i*. | |

APPENDIX 2 - FMEA scoring definitions

| Score | Severity of effects |
|---|---|
| 1 | Does not affect the flow or quality of the service |
| 3 | Causes mild dissatisfaction to the customer |
| 5 | Results in confrontation with customer and additional costs |
| 8 | Customer experiences major impediment and large costs are incurred |
| 10 | Catastrophic failure resulting in litigation |
| | |
| **Score** | **Occurrence** |
| 1 | Less than once a year |
| 2 | A few times a year |
| 4 | Once a month |
| 6 | Once a week |
| 8 | Once a day |
| 10 | Almost every order |
| | |
| **Score** | **Likelihood of detection** |
| 1 | Almost certain |
| 3 | Very likely |
| 5 | Moderate |
| 8 | Remote |
| 10 | No detection opportunity |

APPENDIX 3 – AHP matrices

| **Improve hardware repair and maintenance service productivity** | **Customer perceived service quality** | **Cost-savings** | **Work efficiency** | **Employee satisfaction** | **Ease of implementation** |
|---|---|---|---|---|---|
| **Customer perceived service quality** | 1 | 7 | 3 | 3 | 5 |
| **Cost-savings** | 1/7 | 1 | 1/7 | 1/7 | 1/3 |
| **Work efficiency** | 1/3 | 7 | 1 | 3 | 4 |
| **Employee satisfaction** | 1/3 | 7 | 1/3 | 1 | 3 |
| **Ease of implementation** | 1/5 | 3 | 1/4 | 1/3 | 1 |

| **Customer perceived service quality** | More thorough review of service order backlog in weekly team meetings | Compile all essential documentation for the service into one place | Modify current ERP to enrich service order history data | Acquire a mobile field service solution for maintenance representatives | Replace current ERP system |
|---|---|---|---|---|---|
| More thorough review of service order backlog in weekly team meetings | 1 | 1 | 7 | 1/3 | 1/3 |
| Compile all essential documentation for the service into one place | 1 | 1 | 5 | 1/3 | 1 |
| Modify current ERP to enrich service order history data | 1/7 | 1/5 | 1 | 1/5 | 1/3 |
| Acquire a mobile field service solution for maintenance representatives | 3 | 3 | 5 | 1 | 2 |
| Replace current ERP system | 3 | 1 | 3 | 1/2 | 1 |

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(Appendix 3 continued)

| **Cost-savings** | More thorough review of service order backlog in weekly team meetings | Compile all essential documentation for the service into one place | Modify current ERP to enrich service order history data | Acquire a mobile field service solution for maintenance representatives | Replace current ERP system |
|---|---|---|---|---|---|
| More thorough review of service order backlog in weekly team meetings | 1 | 1 | 3 | 1/5 | 1/3 |
| Compile all essential documentation for the service into one place | 1 | 1 | 5 | 1/3 | 1/2 |
| Modify current ERP to enrich service order history data | 1/3 | 1/5 | 1 | 1/5 | 1/5 |
| Acquire a mobile field service solution for maintenance representatives | 5 | 3 | 5 | 1 | 3 |
| Replace current ERP system | 3 | 2 | 5 | 1/3 | 1 |

| **Work efficiency** | More thorough review of service order backlog in weekly team meetings | Compile all essential documentation for the service into one place | Modify current ERP to enrich service order history data | Acquire a mobile field service solution for maintenance representatives | Replace current ERP system |
|---|---|---|---|---|---|
| More thorough review of service order backlog in weekly team meetings | 1 | 1/5 | 1/3 | 1/9 | 1/5 |
| Compile all essential documentation for the service into one place | 5 | 1 | 3 | 1/5 | 1/2 |
| Modify current ERP to enrich service order history data | 3 | 1/3 | 1 | 1/7 | 1/3 |
| Acquire a mobile field service solution for maintenance representatives | 9 | 5 | 7 | 1 | 5 |
| Replace current ERP system | 5 | 2 | 3 | 1/5 | 1 |

(continued on next page)

(Appendix 3 continued)

| **Employee satisfaction** | More thorough review of service order backlog in weekly team meetings | Compile all essential documentation for the service into one place | Modify current ERP to enrich service order history data | Acquire a mobile field service solution for maintenance representatives | Replace current ERP system |
|---|---|---|---|---|---|
| More thorough review of service order backlog in weekly team meetings | 1 | 1/7 | 1/5 | 1/9 | 1/5 |
| Compile all essential documentation for the service into one place | 7 | 1 | 2 | 1/4 | 2 |
| Modify current ERP to enrich service order history data | 5 | 1/2 | 1 | 1/5 | 1/2 |
| Acquire a mobile field service solution for maintenance representatives | 9 | 4 | 5 | 1 | 6 |
| Replace current ERP system | 5 | 1/2 | 2 | 1/6 | 1 |

| **Ease of implementation** | More thorough review of service order backlog in weekly team meetings | Compile all essential documentation for the service into one place | Modify current ERP to enrich service order history data | Acquire a mobile field service solution for maintenance representatives | Replace current ERP system |
|---|---|---|---|---|---|
| More thorough review of service order backlog in weekly team meetings | 1 | 3 | 5 | 7 | 9 |
| Compile all essential documentation for the service into one place | 1/3 | 1 | 2 | 3 | 7 |
| Modify current ERP to enrich service order history data | 1/5 | 1/2 | 1 | 4 | 5 |
| Acquire a mobile field service solution for maintenance representatives | 1/7 | 1/3 | 1/4 | 1 | 3 |
| Replace current ERP system | 1/9 | 1/7 | 1/5 | 1/3 | 1 |

(continued on next page)

| Summary | | | | | | |
|---|---|---|---|---|---|---|
| Weights of criteria | **43,8 %** | **3,7 %** | **27,2 %** | **17,5 %** | **7,8 %** | |
| | Customer perceived service quality | Cost-savings | Work efficiency | Employee satisfaction | Ease of implementation | Evaluation |
| More thorough review of service order backlog in weekly team meetings | 16,6 % | 11,1 % | 3,7 % | 3,3 % | 51,4 % | 13,3 % |
| Compile all essential documentation for the service into one place | 17,5 % | 15,2 % | 14,7 % | 19,4 % | 22,0 % | 17,4 % |
| Modify current ERP to enrich service order history data | 5,1 % | 5,0 % | 7,5 % | 10,6 % | 15,8 % | 7,5 % |
| Acquire a mobile field service solution for maintenance representatives | 38,8 % | 44,9 % | 55,6 % | 53,4 % | 7,2 % | 43,7 % |
| Replace current ERP system | 22,0 % | 23,8 % | 18,5 % | 13,2 % | 3,5 % | 18,1 % |