UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

Master Thesis

What drives resistance to innovation amongst device makers in the medical radiographic industry?

A qualitative case study investigating the use of microfocus X-ray tubes and the barriers to a widespread usage in the medical radiography

Erik Rudenstam and Victor Tennby

Supervisor: Ethan Gifford

Graduate School

GM0460 V18
Innovation and Industrial Management

Acknowledgements

We would like to extend thanks to Luxbright AB for the help we have received from the company as well as the company making their resources, expertise, and network available. Specifically, we would like to thank Dr. Qiu-Hong Hu for his much-appreciated help with information gathering and providing us with his insights.

Additionally, we would like to thank our supervisor Ethan Gifford for his support as well as all companies and employees that have contributed to our research through partaking in interviews.

i. Abstract

In academia, literature on innovation have over the last few decades predominantly focused on what strategies can help drive acceptance of new innovative products and services. However, the arguably quite high failure rate for market introductions of innovative products indicates that academia and innovative companies should increase the focus on understanding the challenges and pitfalls that could potentially affect the market introduction's degree of success.

Far from all innovations are successfully adopted by consumers, and there may be several situational or contextual user and market related reasons for this. Since the millennia, an increasing amount of research and literature have focus on innovation resistance with the ambition of unearthing the factors that influence the intended users. This field of innovation resistance is as such fairly new, resulting in a lack of generally applicable theories and definitions which may be a consequence of the factors of resistance being situational and contextual and therefore varying between industries and markets. This research focus on understanding what drives innovation resistance within the medical radiographic industry. For means of understanding the intrinsic drivers and barriers of resistance specific to the industry, the research has focused on the case of microfocus technology and medical X-ray.

An innovation introduces change to an industry, and when it does, it will arguably face some resistance among the target customers. Through this case study, the main triggering drivers of innovation resistance within the medical radiographic industry are identified (*unawareness or indifference to innovation,* and *preferences for the status quo*), what main barriers against innovation adoption are created (*visibility, communicability, norms & traditions, usage, information, and risk*), and through what modes of resistance the device-manufacturers resist the innovation (*postponement of adoption,* and *rejection of the innovation*). It is shown that the device-manufacturers resist the innovation to varying degrees, from caution to outright rejection. The innovation resistance is based upon the current lack of information regarding the technology, and inefficient dissemination of the benefits and functionality to alleviate the perceived risks and uncertainties revolving the innovation.

ii. Note of the authors

The following thesis work contains the results of research having performed in order to investigate innovation resistance from actors operating within medical radiography.

The research performed was made possible by the start-up Luxbright, based in Gothenburg, Sweden, which is currently making efforts to commercialize its product and to investigate further appropriate markets for the company's technology. One of the authors have been employed by Luxbright since June 2017 while the other was given a four-month internship at the start of the thesis project. Being employed by the company and performing the thesis research partly on the company's behalf have made it possible to gather information and data from international companies by accessing the network and resources of the company.

Table of Contents

List of Figures and Tables

1. Introduction

"The benefits of an innovation may be purported as attractive by its originators, but the research shows a less-than-enthusiastic reaction among users regarding technological innovations. The expression can be manifested in several ways, but can be collectively termed as resistance to innovation" (Ellen, Bearden, & Sharma, 1991)

1.1. Importance: Identifying innovation resistance

There are many key factors to consider when evaluating the launch of an innovation to the market, for example the novelty of the innovation and potential performance increases, for radical and incremental innovations respectively. And consequently, the adoption and diffusion process of innovation has been widely researched by academia to identify the factors that makes an innovation successfully enter an existing or make a new market. The main focus of research related to successful innovation within the fields of research has been the creation of theories on innovation diffusion, market making and adoption. These maps out the criteria required for successful innovation introduction, which in the long run can be the first step for a sustainable competitive advantage within a highly technological industry.

However, there has been a lack of focus on explaining the reasons for the relatively high failure rates of innovations development projects initiated (Ram, 1987) (Lee & O'Connor, 2003). Not all innovation projects are successfully adopted by customers for many different situational or contextual reasons related to the customers and target markets. As such, there have recently been an incrementally increasing amount of research about innovation resistance, and the factors that influence the target customers of an otherwise functionally superior product to resist or reject the usage of the innovation and favour the existing product selection.

Researchers and product developers know the importance of creating a customer fit for a more successful introduction (Ellen, Bearden, & Sharma, 1991). In many highly technological industries, such as the medical radiographic industry, the development of new innovations, and understanding the needs of the customer is assumed to be a critical key creator of competitive advantage and sustainable value creation. Still there are many innovations that may not be quickly adopted or successfully adopted in the market, opening up to the crucial question and the purpose of this thesis: what are the sources that create customer resistance barriers, and in what ways do they make the customers to resist or reject an otherwise technologically and functionally superior innovation, in the case of an innovation seeking to be introduced to the medical radiographic industry?

The answer to this is to be found from a combination of research within the academic fields of behavioural economics, psychology, marketing, and entrepreneurship, focusing on innovations. In which, the existing research identifies innovation-, personality-, and market related variables that influences the customer's propensity to resist or not. By identifying the variables that may influence the success of the innovation, in either way, the product developer can create channels for product amenability and lower the perceived uncertainty and risks of switching products. Identifying the key success factors of previous innovations for a successful introduction to the market is a common process in development research. However, ignoring the factors that might cause an innovation to be resisted will increase the time for diffusion, and increase the risk of innovation failure.

Several researchers have hinted at the importance of including theories of innovation resistance when developing technological innovations, to increase the chances of a successful introduction to the market, with a short diffuse period, instead of failure. The research field of innovation resistance is relatively new, and thus has no extensive definitions or general theories to rely upon, and often requires different measures of modality or amenability, dependent on what drives the resistance, and what kind of barriers are created.

By adding a process to identify the key pressure-points that can be perceived as risky or uncertain by the users in the R&D-process, innovators can early create measures to reduce or remove the identified resistance or end the project before spending too much resources on a certain failure (Straub, 2009). And with the increasing rate of innovation within high-technological industries, the ability to efficiently assess the feasibility of an innovation in regards of success- and resistance factors, it could be developed to become a competitive advantage for organizations.

1.2. Focus: Drivers and Barriers of Innovation resistance

An innovation can be defined as a product, service or idea (Straub, 2009) that is perceived as something new and novel by the users, not necessarily objectively new, which can be incremental or radical changes to an existing concept or attributes of a product (Ram, 1987). The field of innovation resistance concerns the variables and factors of an innovation that drives the intended customers to resist adoption and the creation of barriers to the use of an innovation, meaning the process of through either passive or active means of user resistance towards an innovation regarding functional or psychological attributes, perceived or realized (Ram, 1987) (Szmigin & Foxall, 1998) (Kleijnen, Lee, & Wetzels, 2009) (Antioco & Kleijnen, 2010) (Talke & Heidenreich, 2013) (Labrecque, Wood, Neal, & Harrington, 2017) etc. Resistance can in broad strokes be defined as any behaviour that serves to maintain the current customer status quo in the face of pressure to alter the status quo and is strongly associated with the degree by which individuals feel threatened by change (Ram, 1987). Additionally, it is central to the current definition of innovation resistance is that resistance is not the obverse to innovation adoption, and they may be present at the same time, but will not be successfully adopted by the target customers until the prior is resolved. Thus, the existing research regarding innovation resistance is much focused on the sources of resistance: what factors drive users to resist an innovation? (Kleijnen, Lee, & Wetzels, 2009); How do organizations overcome the resistance barriers for a successful adoption? (Ram, 1989); How do resistant consumers react to technological innovations (Szmigin & Foxall, 1998) (Laukkanen, Sinkkonen, & Laukkanen, 2008) (Kleijnen, Lee, & Wetzels, 2009)? By defining what innovation resistance is, and how it can be resolved, innovation research can conceptualize more accurate innovation development process models and apply it for more efficient R&D-projects.

Nonetheless, innovation resistance is a very situational phenomenon, and highly dependent on the environmental context of the industry, technology, company and the target customers as to where resistance may arise, and how much it will affect the diffusion of the innovation. According to (Ram, 1987) (Gatignnon & Robertson, 1989) (Szmigin & Foxall, 1998), among others, how and what affects the customer's innovation resistance is based upon what types of risks or uncertainties are experienced or perceived in the learning or evaluation process. On one side, there are the drivers and barriers that arise from factors related to the technological factors of the product itself, and on the other side there are drivers and barriers that arise from psychological factors more related to individual perceptions. So, when we investigate the drivers and barriers of innovation resistance within a high-technology industry, we need to identify the drivers and barriers of resistance, define the nature of the source, as passive or active, functional or psychological, and in what mode of resistance the customers react to the innovation.

1.3. Problem: Innovation adoption and Innovation resistance are two different things

A central problem when investigating innovation resistance is the similarities between what is called drivers of resistance and resistance barriers. "Drivers of resistance" refers to the underlying factors, acting as the source that triggers the resistance to adoption of an innovation, meanwhile, "resistance barriers" is the attributional threshold of the resistance experienced that is needed to be surpassed for accepted adoption (Ram, 1989). Thus, the terms share the sources of resistance, but drivers are the triggers, and the barriers are the result of resistance. Combining the differentiation between drivers and barriers with a classification of active or passive resistance mechanisms, and functional or psychological characteristics, the process of identifying, and solving resistance to innovation, creates for unique solutions for each individual innovation dependent on what is triggering innovation resistance in each unique case.

For a qualitative and explorative study regarding customer resistance when introducing an innovative product to the market this will have several consequences in how the study is conducted: First, we need to identify what barriers can be found to be present within the industry towards the specific innovation, and the barrier characteristics (Ram, 1987). Second, we need to identify the sources of resistance that drives, and through which mechanisms they affect the resistance (Ram & Sheth, 1989) (Kleijnen, Lee, & Wetzels, 2009) (Labrecque, Wood, Neal, & Harrington, 2017). Third, we need to identify the nature of resistance, contextual, situational or individual-based. And last, we also need to then identify what current mode of resistance to the innovation is present among the targeted customers (Szmigin & Foxall, 1998) (Kleijnen, Lee, & Wetzels, 2009).

1.4. Research gap and research questions

Up until this moment, the research of innovation resistance has mainly been focused on:

1. How to form strategies and create consumer products that will be easily adopted and face little to no resistance from the customers. Research has also involved the creation of services.

2. Creating a coherent theory of innovation resistance and theorizing the impact on the field of innovation diffusion and adoption. I.E. promoting the inclusion of innovation resistance models in the decision-making process, as to increase the probability of making the products that will be successful.

But, there is limited research on resistance to an innovation in a highly technological industry where the products are meant to be serving a wide group of individuals, and bound by extensive policy regulations and practices, such as the medical radiographic industry.

Thus, the research questions that will be sought to be answered through this thesis are concerned with the drivers and nature of, and resistance to a specific innovation among device-manufacturers within the medical radiographic industry:

RQ1: What sources of resistance drives the device manufacturers' resistance to microfocus in the medical radiographic industry?
RQ2: What resistance barriers are identified amongst device manufacturers within the industry?

The managerial implication of including resistance to adoption into decision processes, would be that by considering the complex social process where customers form malleable perception influencing their decisions, companies can create more efficient marketing strategies to address cognitive, emotional, and contextual concerns (Straub, 2009). And thus, through the improved processes become less prone to waste significant resources in the development process on innovations that would ultimately be resisted or rejected by the target market (Talke & Heidenreich, 2013).

2. Background

2.1. Inspiration and Scope of the Thesis

The focus of this research was in part driven by the authors employment at Luxbright (see Note of the Authors). The company, a Swedish nanotech start-up founded in 2012 by Dr. Qiu-Hong Hu and Greg Carson, is focused on developing the next generation of X-ray tubes for multiple areas within radiography. The company have developed and patented new technologies for X-ray tubes promising improved image quality, reduced energy consumption and reduced exposure time and radiation dosage. Amongst the technology developed is a new innovative solution for microfocus. As the company is now in the late stage of product development and preparing for market launch, it is important that the intended markets are researched in order to assess the desired market positioning and key selling points. As such, this research, focused on exploring the drivers of resistance towards innovative products in the field of medical radiography, provides market insights for the company.

Luxbright is currently focusing its commercialization efforts on the security industry (incl. passenger and baggage screening at airports and postal/package scanners). Simultaneously the company is eyeing up other industries such as medical radiography, non-destructive testing (NDT), research and geology. The research performed for this study aims at providing valuable insights for Luxbright as the company plans to expand into medical radiography within a two-year horizon. The findings presented herein will provide information about expectations of the industry, what response the company may face when introducing their innovative products to the medtech market and how to most efficiently disseminate the benefits of their technology.

2.2. X-ray Technology

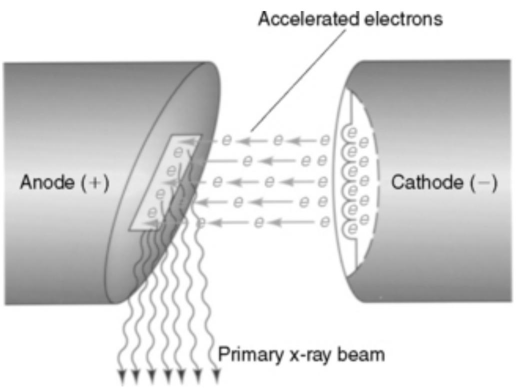
The term X-ray, or Roentgen ray after its discoverer Wilhelm C. Röntgen, refers to an ionizing electromagnetic photon ray characterized by its very short wavelength, allowing it to penetrate materials of varying density. The capability of penetrating different materials allows for non-invasive screening of bones, cartilages or other dense matter. As a result, X-ray screenings have become one of the most preferred analytical technologies for medical imaging. However, as will be discussed in the following sections, the basic principles and functions of medical x-ray systems has been generally unchanged in the last 100 years.

The main components of a modern X-ray system are; an X-ray tube generating the X-ray beam; a generator powering the tube; a detector capturing the image; and the capsulating machine, most often combined with a monitor and control panel.

The X-ray tube is arguably the most critical component of any X-ray system. The tube consists of a cathode that emits a beam of electrons, which are accelerated by the applied voltage, shooting through the vacuum tube towards an anode positioned on the other side of the tube. As the beam of electrons collide with the anode, X-ray photons are created and shoots out from the tube towards the examined object. On the opposite side of the object, one or more detectors are placed acting as image receptors catching the X-ray photons penetrating the object. A simplified comparison of the workings of the detector can be drawn with the old film-rolls used for cameras prior to the introduction of digital cameras. Similar, to the evolution of digital photographic imaging processing, digital radiographic detectors have been developed to work in a similar fashion, shortening the time for imaging processing. However, many applications still use radiographic film instead of the modern digital detectors and flat panel detectors. This thesis will predominantly focus on the resistance to innovation on the components of X-ray systems, more specifically on the X-ray tube and microfocus technology.

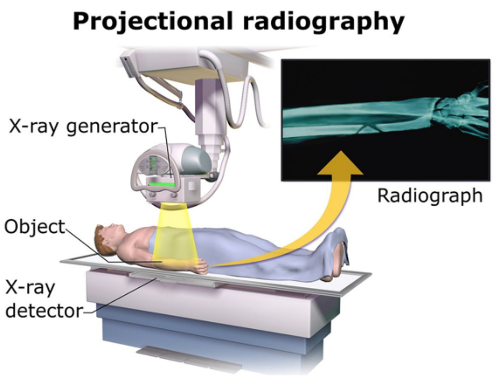
Figure 1 illustrates the basic principle of a conventional X-ray tube. Figure 2 illustrates a radiographic procedure using a projectional X-ray system.

Figure 1: Basic function of a conventional X-ray tube



Source: https://veteriankey.com/anatomy-of-the-x-ray-machine/

Figure 2: Projectional X-ray system



Source: Wikipedia.org

2.2.1. History of X-ray

Conventionally, historians credit German physicist Wilhelm Conrad Röntgen with the discovery of X-ray. Röntgen first discovered X-rays emanating from a so-called discharge tube that he was studying in the late 1800s. He would also become recognized as the first physicist to capture an X-ray photograph in December 1895. The photograph with the title "Hand mit Ringen" (*Eng. "hand with ring"*) depicts his wife's hand and the photograph was published just over a week later.

2.2.2. Important Technological Advancements to date

Table 1: Important Innovations in X-ray Technology

1895	**Wilhelm C. Röntgen discovers X-ray.** Röntgen does not file for patent protection for his innovation and donates his Nobel Prize award money to the University of Würzburg.
1896	Siemens & Haske Company files the first patent 'a working X-ray vacuum tube'
1899	**The Müller-Rapidröhre** Carl H.F. Müller patents the Müller-Rapidröhre, one of the first water cooled tubes allowing for higher radiation
1913	**The Coolidge Tube** William D. Coolidge and General Electric develops and patents the Coolidge tube, the first hot-cathode tube. Tubes with designs based on the Coolidge tube are still produced today.
1935	**Abreugraphy** Abreugraphy, or chest photofluorography, used for mass screening of tuberculosis is developed by Manuel Dias de Abreu
1947	**The First Microfocus X-ray Unit** First Microfocus unit by Cosslett and Nixon
1951	Cosslett and Nixon publish the first paper on microfocus technology
1965	**Introduction of Phase Contrast Imaging** First work on using phase contrast imaging for X-ray
1969	**Microfocus Technology Applied Today** Electromagnetic lens for focusing electron beam (R V Ely)

Sources: R.W. Parish (1986); V. E. Cosslett, & W. C. Nixon. (1951); M. Nascimento (2004)

2.2.3. The Case of Microfocus in Medical Radiography

As shown in table 1, microfocus technology was first introduced in the mid 1900's. Along the years the technology has been refined and adapted. The first microfocus X-ray unit was introduced as early as 1947 by V. E. Cosslett and W. C. Nixon. However, as pointed out by J.C. Buckland-Wright (1976), the machines design restricted the size of the examined specimen to very small objects. As such, in the 1970's, he took initiative to modify the unit with the ambition of increasing its potential application in biomedical research. Although advancements have been made, the technology is still in a relatively early stage of development and adoption as it primarily has been developed for use in research and for industrial X-ray applications.

The first microfocus X-ray tube for commercial use was introduced in the late 1900's and the technology was initially developed as a response to the need for high resolution imaging for non-destructive testing. Microfocus X-ray tubes generate substantially smaller focal spots than conventional tubes, resulting in higher image resolution and greater magnification of the object. To date, microfocus X-ray tubes are almost exclusively used for dental x-ray, research, and industrial non-destructive testing applications. The medical industry has been slow to adopt the technology.

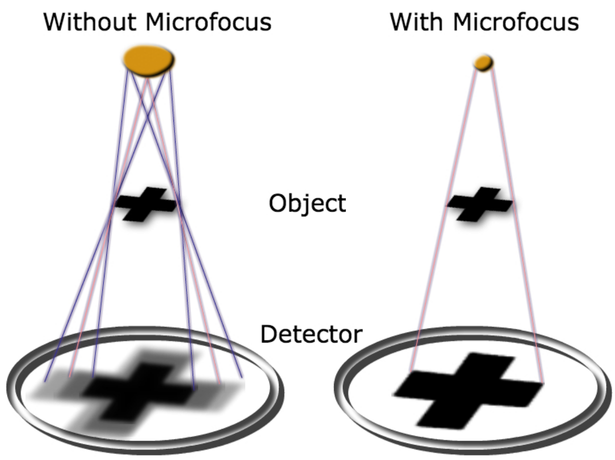
Nonetheless, there are several studies that have proved the clinical benefits of using microfocus technology in medical radiography such as; Microfocal radiography in the diagnosis of childhood renal osteodystrophy (Demiricin et. al., 1998) and Clinical applications of high-definition microfocal radiography (Buckland-Wright and Bradshaw, 1989).

Additionally, in the article "A new high-definition microfocal X-ray unit" (Buckland-Wright, 1989) it is proposed that macroradiographs, which is made possible by microfocus X-ray technology, allow direct and accurate measurement of radiographic features. Moreover, a German study analysing the resolution and radiation exposure of a recently developed mammography unit utilizing microfocus technology found a 50% reduction in radiation dose at a 1.7 magnification (Post, Hermann & Funke, et. al., 1997).

The potential of microfocus technology for medical research was investigated in a study published in the journal NDT & E International in 1993 (Wevers et. al, 1993). The study examined the potential of using microfocus radiography as a tool to correlate nuclear magnetic resonance imaging on liver cancers by examining the effect on rats. Furthermore, the study found benefits of microfocus applications for examining bone mineral content and bone mineral density which allows for the monitoring of bone loss as a result from for example nonsteroidal anti-inflammatory drugs (class of drugs used to reduce for example pain and fever). The study concluded that microfocus radiography technology provides clear and sharp images as well as improved contrast as scattered radiation is not recorded by the detector.

Figure 3 below, shows an illustrative comparison of non-microfocus and microfocus radiography and the resulting imaging quality.

Figure 3: Imaging comparison of tubes with/without Microfocus technology



Source: Illustration by the authors

With the clinical benefits of microfocus X-ray for medical radiography proven by several studies, and the embracement of the technology by the NDT industry, it begs the question why the industry of medical radiography is yet to fully adopt the technology. As such, this thesis explores the drivers of resistance towards innovative products, such as microfocus X-ray tubes, in medical radiography.

The purpose of the thesis is to apply the existing theories of innovation resistance in medical radiographic industry. Therefore, to add as a complement to the literature review, the following section will briefly describe the history of medical x-ray imaging and the industry.

This study, is limited to radiography which covering X-ray and X-ray applications. For purpose of clarification, radiography differs from the more commonly used term ‘radiology’ as radiology encompasses all imaging technologies applied within medicine, including but not limited to X-ray, ultrasound, nuclear medicine, positron emission tomography (PET) and magnetic resonance imaging (MRI). Medical radiography includes X-ray applications such as projectional radiography, computed tomography (CT), bone densitometry, fluoroscopy, tomosynthesis and contrast radiography.

3. Theoretical framework

3.1. Theoretical Perspective

The research conducted within the boundaries of this paper follows conventional business research processes. The research strategy, presented in section 3.2., has been chosen based on the inherent features of the study and research paradigms.

An inductive approach has been chosen for the study as the research questions stipulated in the section 1.4 is not answered by existing literature due its specific nature of the case study. The inductive approach of the study allows for using observations made during the study to generate a continuously revise the hypothesis. Nonetheless, an extensive literature review will be conducted as it grants the generation of additional insights by weighing the observations made against the literature.

In regards to the research philosophy or epistemological standpoint, this research adheres to the theory of interpretivism. The study is concerned with the subjective meanings of a phenomena. The interpretivism approach grants the possibility to focus on the human behaviour of the social entities and to capture the subjective significance and meaning of a social action. Additionally, the interpretivism approach suits the purpose of this research as it facilitates understanding of the human behaviour rather than explaining it (Bryman & Bell, 2013).

Qualitatively it must be stated that the research performed in the study may affected by personal subjective values of the authors and their interpretations of the literature and data. The research topic was inspired, and asked for by the authors employees, Luxbright AB. This connection allowed for a research trip to Vienna, but makes it clear that the research cannot be viewed as fully independent. The formal research questions and the results of the study are not linked to the company, or the authors employment.

3.2. Research Strategy

As the primary goal of the study is the generation of a hypothesis, an inductive qualitative approach is used to accumulate the data required to empirically answer the stated research questions. This approach aligns with Bryman & Bell (2013), in how a qualitative study should be approached when the focus is on the generation of a new hypothesis.

Bryman & Bell (2013), stress the importance of addressing any and all practical issues of the study as well as the degree to which the research may be affected by the personal values of the researchers. As such, it should be accentuated that the researchers were, before and during the time of the research, employed by the company on which behalf the research was conducted. This implies that that the research cannot and should not be viewed as fully independent. Nonetheless, the situation is of benefit for the research as it allowed for more comprehensive and inclusive insights. Even more importantly for the gathering of data, the researchers were allowed access to the company's network of contacts and as such allowed for a greater data sample than what could have achieved without it.

Moreover, it should be emphasized that the topic of the research has not been dictated in its entirety by the company. Rather it was the researchers who proposed the topics. As such, the study and its final outcomes is of academic merit. However, the dual roles as employees and researchers does impact the research method and evaluation.

3.3. Literature Review

In the introduction innovation resistance was broadly explained as the negative customer response to an innovation, based on their perceptions and evaluations. And further, an initial connection between the more established theories of innovation adoption and innovation resistance was created. In this section, will provide a more detailed review of the relevant theories and literature regarding innovation resistance. First, it will go in the order of stating the needs for resistance research as a complement to current innovation research. Second, how the origin and underlying factors of innovation resistance among customers is defined by previous researchers. Third, a description of the resistance barriers identified by previous researchers, and their categorization of distinct attributes. Fourth, defining the sources and inherent mechanisms of the resistance drivers identified within the literature. And, last providing an overarching definition and the attributes of different modes of resistance described by previous literature.

The primary sources of information used in the study was collected from academic journals, articles, and books available through *Gothenburg University Library*, and the databases *Scopus*, *Springer Link*, and *ResearchGate* available through the library. To ensure an academic quality to the sources used, the number of citations made to the source, and peer-reviews were taken into consideration in the selection of sources to reference and use.

The literature was located through different combinations of the keywords including, but not limited to variations of; *innovation, management, resistance, adoption, rejection, medical radiography, medical industry, medicine* and *x-ray*. Through appropriate sources fitting the preceding constraints, additional relevant sources to the purpose of the study was found and used, as long as they were within the limitations and criteria of the search scope.

The sources selected to be used in the study have been limited to only include sources published after 1985. The earlier sources are important to include as they first introduced the concept of innovation resistance as a field of study, and although they might not be perceived as contemporary in the present they provide the necessary background for the importance of studying innovation resistance as a part of the innovation development process.

3.3.1. Technology Adoption & Resistance to Innovation

Before 1985 most of the literature involving innovation mostly restricted itself to the adoption and the diffusion perspectives of innovation. The reason for this limitation or restriction to what innovation-researchers study is according to Ram, S. in the article "*A model for innovation resistance*" (Ram, 1987) a "pro-innovation bias", where many researchers studying the processes of innovations has a predisposition to assume that all innovations are good for the customers and are always a certain improvement over the existing alternative products available in the markets. Straub (2009) points out that many adoption and diffusion theories fails to properly map the underlying cognitive and emotional reasons for and against the adoption of innovations (Straub, 2009), and thus often disregard contextual customer concerns as a reason for innovation failure.

The criticism to previous research can be summarized as such; the perception that all innovations are always perceived by the customers as an improvement over the existing selection of products, would make it impossible to find an reasonable explanation to the high rates of innovation failures across a multitude of industries, compounding with research that has primarily focused on the diffusion and acceptance of successful innovations, thus fails to take the non-successful innovations in consideration when building adoption and diffusion theories.

The fundamental trigger for customers to resist innovations is noted by Ram, S. (1987), and later (Gatignnon & Robertson, 1989) (Szmigin & Foxall, 1998) to be the underlying nature of an innovation and what it usually first imposes when in contact with customers, novelty, or change, a disruption to the existing *status quo*. It is noted that it is the nature of change or disruption that is caused by an innovation that is primarily being resisted by customers, not the product itself (Schein, 2010). And the psychological, and rational behavioural response to change is resistance (Ram, 1987) (Ellen, Bearden, & Sharma, 1991). And thus, it would be unexpected that customers would readily accept innovations with varying degrees of novelty or radicalness, without some of cautiousness or reservations.

3.3.2. Defining innovation resistance

Many studies researching about innovation failure utilizes the concept of innovation resistance as a part of the rejection. The definition of what innovation resistance is and how it materializes varies to some degrees. Customer resistance (or Consumer resistance to innovation (Szmigin & Foxall, 1998)) is defined from several attributes and factors and is conceptualized as the conscious choice to resist an innovation because it is perceived to pose a risk to change a satisfactory status quo or because it conflicts with the customers' belief structure (Ram, 1987) (Gatignnon & Robertson, 1989) (Kleijnen, Lee, & Wetzels, 2009). To strengthen the argument of resistance to change, it is shown that the current status quo is an important reference point for individual customers, and there is a predicated tendency to prefer the current products, regardless of whether an innovation has a higher relative advantage (either in functionality, ease of use or economic value) (Falk, Schepers, Hammerschmidt, & Bauer, 2007).

Similarly, behavioural psychology research indicates that there is a customer tendency to prefer the tried and proven products when faced with an innovation (Hetts, Boninger, Armor, Gleicher, & Nathanson, 2000), meaning that the more disconnect there is in functionality or traditions between the old technology and the new technology, the more likely the innovation is to be resisted by the intended customers (Ram, 1989). A presence of perceived psychological switching costs can thus affect the customers' resistance to innovations (Garcia, Bardhi, & Friedrich, 2007).

Alternatively, customer resistance to innovation has been theorized to be triggered by customer attitude towards the specific functions of innovations (Ellen, Bearden, & Sharma, 1991), in combination with an inherent conservatism of customers, or a behavioural inclination to resist change (Szmigin & Foxall, 1998); as the result of unfavourable active observations and evaluations of an innovation (Kleijnen, Lee, & Wetzels, 2009). And for how and when attributes trigger resistance towards innovation is shown to be dependent on either customer characteristics, the situational context, or as a combination of both (Rogers, 1995) (Szmigin & Foxall, 1998). For the purpose of the thesis regarding an industry involving products that could possibly harm the intended end-users, it is important to use a definition of customer resistance that includes both functional-, psychological attributes, and both customer characteristics and situational context.

It is important to note that customer resistance to innovation is not the same as "anti-consumerism", as end-result of customer resistance is more ambiguous than simply not buying a product. The resistance to an innovation is not the obverse of innovation adoption (Ram, 1987), meaning that an innovation can experience both resistance and acceptance over its lifetime, but for successful adoption, it can be implied that it is not enough for an innovation to exhibit and control adoption-specific characteristics (Rogers, 1995), but also a need to manage and reduce resistance-specific characteristics (Gatignnon & Robertson, 1989).

The drivers for and drivers against adoption differentiate qualitatively, and in how they influence the customer varies as well, which means that the approaches and strategies needed to overcome a resistance barrier are different from the approaches aiming to promote adoption of an innovation (Claudy, Garcia, & O'Driscoll, 2015). At the same time, researchers argue for that there are some degrees of overlap between the factors affecting the reasons for and against adoption (Herbig & Day, 1992), implying that there is ambiguity to the understanding how the relationship between the factors and attributes influencing reasons for and against adoption of an innovation.

3.3.3. Innovation resistance barriers and drivers of resistance

The literature use the concept of resistance barriers, the erection of barriers to adoption, with a resistance threshold dependent in the degrees of conflict with current functionality and customer behaviours (Ram, 1987). These barriers are conceptualized to be sourced from several different product-, consumer-, contextual-, and situational specific factors (Kleijnen, Lee, & Wetzels, 2009), triggering customers to resist an innovation and create resistance barriers.

Even though there is an overlap of similarities of the theories between what is defined as barriers and drivers, we will define barriers and drivers respectively, for clarification, as: An innovation resistance barrier, is the resistance-threshold dependent on the resistance drivers, and needed to be surpassed through amenability and learning to be successfully adopted (Ram, 1987) (Szmigin & Foxall, 1998) (Garcia, Bardhi, & Friedrich, 2007); A driver of resistance is the underlying triggering source that will prompt the user to resist adoption of an innovation (Kleijnen, Lee, & Wetzels, 2009) (Labrecque, Wood, Neal, & Harrington, 2017).

From the research related to innovation resistance, it is shown that customer resistance to innovations does not only depend on factors relating to the functional attributes of an innovation, but it is also highly dependent on psychological attributes, the contextual and situational timing of the introduction of the innovation, meaning that customers might not be behaviourally or attitudinally ready to accept an innovation, or a lack of complementary products deters the willingness to adopt a new technology at the time of introduction to the market.

The impact and effects of the barriers resistance-threshold and their drivers are shown to diminish over time and highly affects the timing of customer adoption, and can be exhibited as a passive or active behaviour depending on what type of sources of resistance is triggering customer reaction.

3.3.4. Innovation resistance barriers

The research regarding innovation resistance barriers is much based on the initial research of Ram (1987) and Ram & Sheth (1989). In the research of customer resistance to innovation, resistance barriers that cause non-adoption (Ram, 1987), are categorized into two main groups: *Functional barriers*, which relates to (1) usage patterns of the product, in how it works with current practices and routines. (2) The performance-to-price ratio, or the value of the product in comparison to the existing products currently used. (3) Risks associated with the usage of an innovation, physical, economical, and functional risks (not working properly). The functional barriers relate to the innovation-specific characteristics and are according to (Ram & Sheth, 1989) more likely to occur the more the customers perceive an innovation as radical and likely to introduce significant changes through the adoption of the innovation. The barriers arise when the customer perceive or has evaluated any of the product attributes as dysfunctional or inadequate for the needs and usage expectations of the customer (Bagozzi & Lee, 1999) (Nabih, Bloem, & Poiesz, 1997).

The other group of barriers are called *Psychological barriers*, as they occur from (1) usage clashes with existing traditions and norms or how something is supposed to be or how it is done. (2) Perceived product image, related to the market, industry image and country of origin (Ram & Sheth, 1989). And thus, highly dependent on individual-specific characteristics and the situational context or customer perception of risks when considering the relative advantage of switching from current technologies.

The concept of barriers is also used by (Garcia, Bardhi, & Friedrich, 2007), where they instead reduce the number of innovation resistance barriers down to 5 barriers, in a similar concept to (Ram, 1987), excluding the overarching categorization of functional and psychological barriers and including behavioural drivers that create barriers in the theory, making it closer to a hybrid between the drivers of resistance (Kleijnen, Lee, & Wetzels, 2009) and the barriers of resistance used by (Ram, 1987) (Ram, 1989) (Ram & Sheth, 1989). Furthering the risk of confusing the difference between drivers and barriers. The barriers they identify has an overlap with the preceding research, in where their driver/barriers are caused/created by a customer status quo preference; value and information asymmetries; perceived risks and the will to hold purchase until mitigated; conflict with current norms and traditions; and the product, company or market image.

The grouping of barriers is an expansion of the previous categorization of characteristics that Ram, S. identified for his Technology Acceptance Model in *A model of innovation resistance*, 1987, in which he first defined the boundaries of innovation resistance and the inherent attributes of the phenomenon. In a second paper (Ram & Sheth, 1989), the concept evolved and was further defined and categorized into the two major groups of resistance barriers, which seem to be generally accepted concept by succeeding researchers within the field of innovation resistance (Laukkanen, Sinkkonen, & Laukkanen, 2008), (Antioco & Kleijnen, 2010), (Talke & Heidenreich, 2013) & (Labrecque, Wood, Neal, & Harrington, 2017).

The table below is a summary of the barriers identified by researchers, categorized by type of barrier, a short description, which researchers that mentions what barriers, and lastly which inherent type of characteristics each barrier exhibit, functional (innovation-specific) or psychological (individual- or situation-specific).

Table 2: Barriers of Resistance

Barrier	*Description*	*Source*	*Barrier Characteristics*
Value	Perception regarding the relative advantage, *value of use*, over existing alternatives. Higher relative advantages lower resistance.	(Ram, 1987) (Lee & O'Connor, 2003) (Laukkanen, Sinkkonen, & Laukkanen, 2008)	Functional
Complexity	Complexity of the idea (to understand), and complexity of execution (to use).	(Ram, 1987)	Functional
Trialability	Relating to the ease of testing and evaluating the innovation before adoption. Relates to perceived risks. Lower trialability increases the perceived risks, and resistance.	(Ram, 1987) (Nabih, Bloem, & Poiesz, 1997)	Functional
Compatibility	Customer's perception regarding the compatibility with existing patterns, products, and customer needs. Higher compatibility lowers the resistance.	(Ram, 1987) (Garcia, Bardhi, & Friedrich, 2007)	Functional

Co-dependence	Customer’s perceived dependence on complementary products for optimal innovation functionality	(Laukkanen, Sinkkonen, & Laukkanen, 2008)	Functional
Visibility	Related to the trialability, concerns the possible difficulty to observe others using the innovation	(Moore & Benbasat, 1991)	Functional
Communicability	Perceived difficulties in conveying and disseminating the benefits of adoption. The two components: tangibility of the usage benefits; and the ability to communicate said benefits.	(Ram, 1987) (Moore & Benbasat, 1991) (Bagozzi & Lee, 1999)	Functional
Amenability	The ability to customize and modify the innovation, for better customer fit and satisfaction. Low levels of amenability lead to high resistance or rejection.	(Ram, 1987) (Szmigin & Foxall, 1998)	Functional
Realization	How soon the customer can expect the benefits of using the innovation to be realized. Lower rates of realization create higher barriers.	(Ram, 1987)	Functional
Norms & Traditions	Occurs when the innovation is perceived to be in conflict with the customers group-, social- or family-values. Higher perceived usage conflict increases the resistance to the innovation.	(Ram, 1987) (Garcia, Bardhi, & Friedrich, 2007) (Laukkanen, Sinkkonen, & Laukkanen, 2008) (Antioco & Kleijnen, 2010)	Psychological
Image	Perceived negative association of brand, industry or country of origin.	(Ram & Sheth, 1989) (Antioco & Kleijnen, 2010)	Psychological
Usage	Related to *compatibility*, and perceived usage pattern inconsistency usage of an innovation with past experience, can disrupt customer patterns and create barriers. The higher discrepancy, the higher barrier.	(Ram & Sheth, 1989) (Herbig & Day, 1992) (Laukkanen, Sinkkonen, & Laukkanen, 2008)	Psychological
Information	From the information asymmetries, creating uncertainty regarding benefits and risks.	(Ram & Sheth, 1989) (Garcia, Bardhi, & Friedrich, 2007)	Psychological

Risks	Barrier raised due to perceived risks or hazards, regarding *functional*; improper or unreliable, *physical;* harmful to use, *economic;* low economic value to use, and *social;* repeated use is disapproved by relevant social groups.	(Ram & Sheth, 1989) (Stone & Grønhaug, 1993) (Garcia, Bardhi, & Friedrich, 2007)	Psychological

:

3.3.5. Drivers of innovation resistance

According to Ram, S. & Sheth J.N. (1989), innovation resistance is caused by two major reasons: (1) an innovation might create some high-degree of change in the consumers' daily work, and disrupt the established daily routines of the current products used and (2) that the innovation may conflict with the consumers' current belief structures (for example; Chinese X-ray tubes are inferior in quality in comparison to European/Japanese X-ray tubes.) (Ram & Sheth, 1989).

(Kleijnen, Lee, & Wetzels, 2009) further develops the concept of categorization of diverse types of resistance, defines them as behavioural and perceptual drivers for resistance and puts them in relation to how the customers choose to act when prompting resistance to an innovation, i.e. Rejection, postponement or opposition, and they categorize the resistance from how customers react, rather than the nature of the cause to resistance.

From the literature, the drivers of innovation resistance can be compounded into 10 groups of customer behaviour and perceptions: (1) Physical risk; (2) Functional risk; (3) Social risk; (4) Economic risk; (5) Perceived switching costs; (6) Information overload; (7) Existing usage patterns; (8) Traditions and norms; (9) Unawareness or indifference to innovations; and (10) Preference for status quo, or a disinclination to change. (Labrecque, Wood, Neal, & Harrington, 2017) expands the categorization of drivers by including *passive* or *active* resistance, a concept of resistance mechanisms developed by (Talke & Heidenreich, 2013), to define at what stage of the innovation adoption stage a customer can be expected to develop resistance to the innovation, and how to most efficiently reduce the consequences (see section below).

3.3.6. Active or Passive resistance

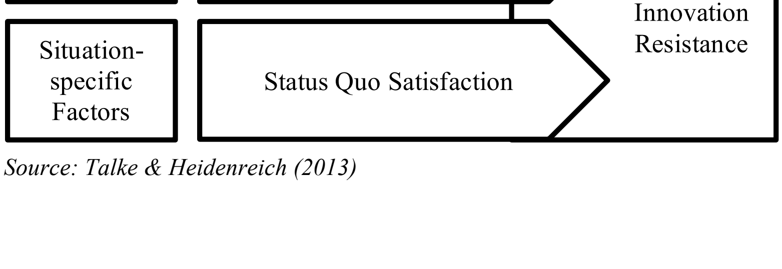
(Talke & Heidenreich, 2013) builds upon previous innovation resistance literature to include a differentiation between resistance mechanisms described as *active resistance drivers*: an attitudinal outcome following an unfavourable innovation evaluation; and *passive resistance drivers*: resistance following a consumer predisposition to actually resist innovations prior to innovation evaluation; as they argue that resistance can be present among target customers even before an innovation evaluation can be made, and thus would require a distinction to develop appropriate responses in innovation processes.

3.3.6.1. Passive Innovation Resistance

Passive resistance can be described as the resistance from customers to the changes that occurs when first introduced to an innovation. The resistance comes from 2 factors; first, customer-related inclinations to resist change, and secondly, the contextual and situation-specific factors that determines the customer satisfaction with the current technology. As (Ram & Sheth, 1989) and (Szmigin & Foxall, 1998) describes, it is shown that the uncertainty of change is enough for customers to resist a new technology, even without deliberately evaluating the product (Nabih, Bloem, & Poiesz, 1997). And similar to attribute tolerance threshold of users found by (Ram & Sheth, 1989), it can be found that as soon as passive resistance exceeds an adopter-specific threshold, customers will engage in such behaviour to maintain the current status quo, in the face of pressure to change and adopt an innovation (Bagozzi & Lee, 1999).

(Talke & Heidenreich, 2013) implies that passive innovation can be relayed either as a dependence of individuals’ inclination to resist change or a satisfaction with the current status quo (Ram, 1987), or more akin to as (Bagozzi & Lee, 1999) and (Szmigin & Foxall, 1998) states it, as a combination of the two.

Figure 4: Sources of Passive Innovation Resistance



Source: Talke & Heidenreich (2013)

Furthermore, the resistance to change is more than just a behaviour in a specific situation, as (Talke & Heidenreich, 2013) argues for a personality trait connection between individuals and resistance to change, thus based on psychological characteristics and behaviour triggered by change, a perceived loss of control (Bagozzi & Lee, 1999), akin to what is theorized by (Ram, 1987) and (Garcia, Bardhi, & Friedrich, 2007) of the psychological switching costs of a customer when evaluating a new product. This psychologically correlated attachment to the status quo, can and is getting in the way of customers' ability to properly evaluate innovations with proposed superior qualities (Bagozzi & Lee, 1999). The reluctance to give up old habits is likely to discourage customers from actively dealing with new products, the unresponsiveness to alternatives and behaviour develops into innovation resistance (Talke & Heidenreich, 2013). Passive innovation resistance can be summarized as the resistance drivers that results in the creation of resistance barriers dependent on adopter- and situation specific factors (Ram, 1987) (Ram & Sheth, 1989) (Laukkanen, Sinkkonen, & Laukkanen, 2008) (Kleijnen, Lee, & Wetzels, 2009).

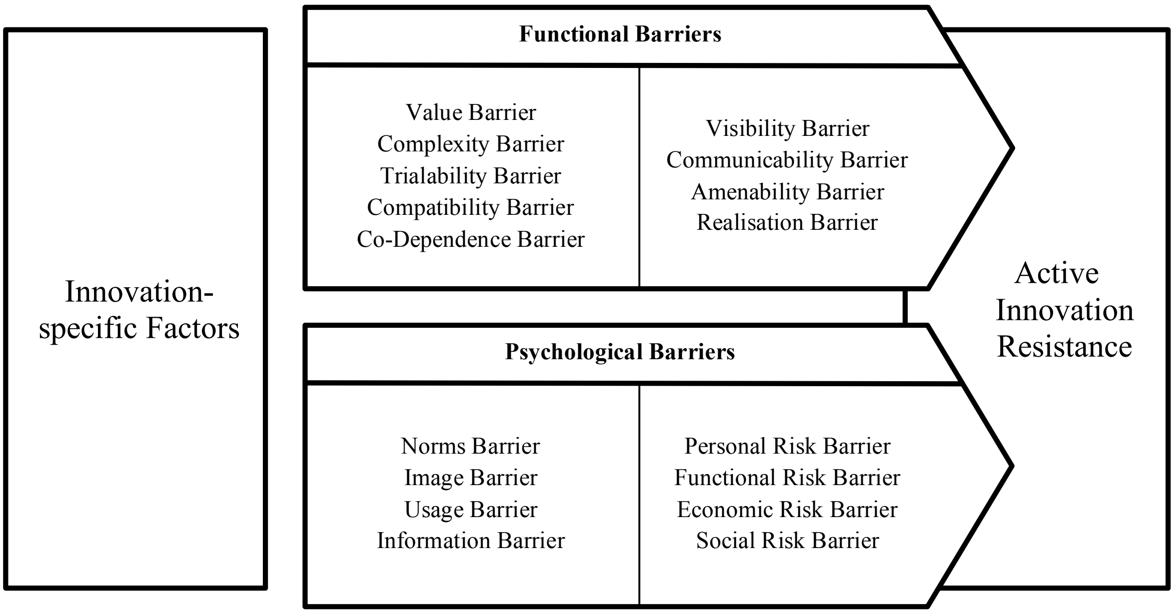
3.3.6.2. Active Innovation Resistance

Active innovation resistance is defined as (Nabih, Bloem, & Poiesz, 1997) the attitudinal outcome of an unfavourable new product evaluation. This type of resistance is a more active and deliberative form of resistance highly dependent on innovation specific factors as a cause for resistance. It is described as a deliberative non-purchase behaviour following a negative evaluation of an innovation. Can also be defined as the conclusion of the customer's perceptions regarding certain attributes that does not meet their expectations when evaluating the innovation (Laukkanen, Sinkkonen, & Laukkanen, 2008), and thus a driver for creating resistance barriers specific to the innovation arise. And as theorized by (Ram, 1987) and later (Kleijnen, Lee, & Wetzels, 2009), once the barriers exceed specific adopter tolerance thresholds, the users will hold a negative attitude towards the innovation until the threshold is surpassed. Active innovation resistance can come from customer's rejection based on the perceived or actual product functionality inadequacy or conflicts with social norms, values and individual usage patterns (Ram & Sheth, 1989)) (Bagozzi & Lee, 1999).

Active resistance to innovation can thus be summarized as the resistance drivers resulting in innovation-specific resistance barriers (Talke & Heidenreich, 2013) and can be divided into functional and psychological barriers in relation to innovation-specific factors (Ram, 1987)

(Ram & Sheth, 1989) (Laukkanen, Sinkkonen, & Laukkanen, 2008) (Kleijnen, Lee, & Wetzels, 2009).

Figure 5: Sources of Active Innovation Resistance



Source: Talke & Heidenreich (2013)

The following table below is a summary of the identified drivers of resistance to innovations, categorized with definitions, contributing researchers, and what type of resistance mechanisms each driver exhibit.

Table 3: Drivers of Resistance

Driver	*Description*	*Source*	*Mechanism of resistance*
Physical risk	Not adopting due to possible physical risks	(Ram & Sheth, 1989) (Stone & Grønhaug, 1993)	Active
Functional risk	Not adopting due to perceptions regarding uncertainty of complementary functionality with existing or future products	(Ram, 1989) (Ram & Sheth, 1989) (Szmigin & Foxall, 1998) (Antioco & Kleijnen, 2010)	Active

Social risk	Not adopting due to concerns regarding other customers' evaluations	(Ram, 1989) (Ram & Sheth, 1989) (Fain & Roberts, 1997) (Dholakia, 2001)	Active
Economic risk	Not adopting due to difficulties determining the innovations true value, or whether the price will change over time	(Ram, 1989) (Ram & Sheth, 1989) (Dhebar, 1996)	Active
Perceived switching costs	Not adopting due to difficulties of learning or costs related to learning the new over keeping the old (not exclusively economic factors)	(Garcia, Bardhi, & Friedrich, 2007)	Active
Information overload	Customers response to the increasing rate of information, or due to a preference of using familiar products over new complex innovation that requires considerable amount of information to properly evaluate	(Herbig & Day, 1992) (Cox & Cox, 2002)	Active
Existing usage patterns	Not adopting due to not able to integrate an innovation into a user's established pattern of use, when there is no desire to change	(Ram & Sheth, 1989) (Herbig & Day, 1992) (Szmigin & Foxall, 1998) (Kleijnen, Lee, & Wetzels, 2009)	Active
Traditions and norms	Not adopting due to the customers' traditions and norms are aligned to the usage patterns of the existing products and less compatible with the new product	(Ram & Sheth, 1989) (Herbig & Day, 1992)	Passive
Unawareness or indifference to innovations	Not adopting due to continued use of existing products when not knowing or thinks the innovation is not relevant for their needs	(Rhoda, 2010) (Labrecque, Wood, Neal, & Harrington, 2017)	Passive

Preference for status quo, disinclination to change	Not adopting due to customers' inclinations to resist change, or content with the current situation	(Ram, 1989) (Ram & Sheth, 1989) (Ellen, Bearden, & Sharma, 1991) (Szmigin & Foxall, 1998) (Bagozzi & Lee, 1999) (Talke & Heidenreich, 2013)	Passive

3.3.7. Modes of user resistance towards innovations

In the article by Kleijnen et al (2009) they further develop the concept of resistance and rejection of an innovation from rejection being "not-trying" the innovation (Szmigin & Foxall, 1998), to instead classify it as three distinct types of customer behaviour and response depending on how the innovation is rejected by the customer (Kleijnen, Lee, & Wetzels, 2009). The research considers the antecedents of consumer resistance and shows that different drivers have different impact upon the customers in relation to innovation barriers.

3.3.7.1. Rejection

Rejection of an innovation is not due to the lack of knowledge or awareness of the innovation, but it is rather an active choice by the customer to resist based on their evaluation of the product from the current available information. This results in a strong customer disinclination to adopt the innovation, and the rejection of an innovation is strongly correlated with customers perceived uncertainties and risk of an unproven innovation (Kleijnen, Lee, & Wetzels, 2009). Additionally, it can also be correlated to individual customers' reluctance to change a satisfactory status quo (Ram, 1987) or usage pattern rigidity (Gabiere, Chern, Hahn, & Chiang, 2004). The user rejection should prompt amenability to modify the innovation to better suit the needs of the user (Szmigin & Foxall, 1998). Rejection of an innovation can thus be the result of either passive or active resistance drivers resulting in either functional or psychological barriers. These are dependent on either individual-specific or innovation-specific factors, depending on at what stage of evaluation process the customer is rejecting the innovation.

3.3.7.2. Postponement

A postponement of an innovation adoption happens when the customer evaluates and finds an innovation acceptable, but only principally, and thus, will not adopt the innovation at the present moment until a new evaluation can be made in the future (Szmigin & Foxall, 1998). The customers will resist adoption until triggering situational- and innovation-specific factors, such as design, complementary assets etc. are more suitable for needs of the target customers, or until suspicions and uncertainties regarding the realized or perceived risks and performance of an innovation is resolved with new information (Ram, 1987) (Kleijnen, Lee, & Wetzels, 2009). Postponing the adoption of an innovation is a less final user decision than rejection (Greenleaf & Lehmann, 1995), as the customer is likely to re-evaluate the innovation when the latest information is available (Szmigin & Foxall, 1998). As this response is more likely to be driven by situational factors (Szmigin & Foxall, 1998), and as (Dhebar, 1996) finds, this type of pattern is often related to technology innovations, where customers worry about investing too early in segments with rapid introductions of new and improved versions would leave the consumer with obsolete equipment. Postponement thus relates to active resistance and innovation specific-factors.

3.3.7.3. Opposition

Out of the identified modes of user resistance, opposition can be viewed as the most severe form of resistance to adopting an innovation. Opposition is argued the most aggressive form or customer resistance identified by (Kleijnen, Lee, & Wetzels, 2009), which conflicts with (Szmigin & Foxall, 1998), which notes the opposition to be more likely to lead to rejection, but the customers are likely to try the innovation before outright rejection. (Szmigin & Foxall, 1998) argues that the end-result of opposition is more ambiguous, and from a pro-active search for more information, the customer is equally likely to accept, or further oppose and reject an innovation based on the current information. The implication according to (Kleijnen, Lee, & Wetzels, 2009) is that customer opposition is mainly driven by the current norms and traditions of the customer environment. And as such, the opposition of an innovation might either stem from a staunch rejection of the innovation and belief in the unsuitability of an innovation, the disruptions to habits, or even a perceived relative disadvantage to the extent that the customer might feel a need to "attack" the product to make it fail (Kleijnen, Lee, & Wetzels, 2009). It defined as a form of innovation sabotage where the customers and conflicting parties can actively engage in strategies and channels to prevent the successful adoption of the innovation (Davidson & Walley, 1985). Opposition is thus a much more active form of innovation resistance caused by customer-specific psychological barriers.

As the research is not definite in the ranking of the levels of severity of the modes of resistance, it will require a subjective consideration of how it can reasonably be ranked. It is mostly concerning to if customer-rejection or customer-opposition to innovation is the most severe mode of resistance. One argument is that customer-rejection is the most severe (Szmigin & Foxall, 1998), from the reasoning that not wanting to engage with the innovation is a final decision from the side of the customer. Thus, not even considering of evaluating the product, now or later. Or, the other argument is that customers opposing a specific innovation is more severe, based on that customers and interest groups pushing back in retaliation can have a greater effect than users simply not engaging with the innovation (Kleijnen, Lee, & Wetzels, 2009).

In this thesis, we consider the order *postponement, rejection* and *opposition* to be the most reasonable order. First, customer resistance in the form of postponement, is a positive evaluation of innovation-specific factors, but just not perceived as suitable to be adopted for the moment for several reasons. Second, customer resistance in the form of rejection, should be viewed as less severe than opposition simply because not engaging with the innovation means that the customer will never consider evaluation, and thus not a part of the target customers. Third, customer resistance in the form of opposition, should be viewed as the most severe form of resistance to an innovation, from the reasoning that actively pushing back and creating conflict within the targeted customer-base will always have a greater effect than having customers simply not participating in the evaluation of the product.

4. Methodology

The research performed in this study is concerned with identifying the reasons device manufacturers in the medical radiography market have for resisting a new product innovation, i.e., what would make these companies refrain from adopting the product. For the purpose of answering the research questions, this study has employed qualitative methods including a case study based on an inductive approach.

For the purpose of generating new theories, and answering the research questions, this thesis will perform a case study, with an inductive qualitative, and exploratory study approach with the ontological perspective of interpretivism.

Basing the research on a case study is generally good for digging deeper into questions as it allows for a greater micro perspective. However, case studies typically suffer from weaknesses connected to subjectivism. Findings from case studies are typically related to a specific context and as such, generalizing the findings and attributing them to a larger population is thus exceedingly complicated and will most likely decrease the reliability of the study as findings from one actor may not be applicable on others.

Nonetheless, a case study centred on an industrial analysis can provide insight and valuable information on different approaches taken by different actors, especially when seeking to understand the subjective meaning of the social actions. To understand the individual specific, respectively industry specific, drivers of resistance and barriers to adoption, this thesis make use of a series of semi-structured interviews to uncover information concerning what drivers affect their attitude towards introduction of new innovative products.

4.1. Research design

The research performed herein takes the form of an industry focused single-case investigative study exploring customer resistance to innovation or, more specifically, what intrinsic drivers there are for customer resistance towards new innovative products in the field of medical radiography.

The decision to conduct a highly contextual single-case investigative study focused exclusively on the field of medical radiography is motivated by a few different factors. Firstly, the lack of literature with focus on the specific industry and thus the need to reduce the void. Secondly, radiography, and the technology thereof, have for the last few decades arguably remained largely unchanged with only small incremental innovations having been made. As such, one would wonder why such a large, globalised and highly competitive industry, with product offerings that almost categorically carry high margins and increasing demand, have remained in a status quo in regards to further technological advancements.

4.2. Limitations

The time constraint of this study, allowing for only four months to conduct the full research and analysis limits the possible scope and depth of the study. Additionally, the sample size and number of interviews that could be conducted was affected by the time constraint. As the study moreover takes an investigative inductive approach in order to research an area of which there is limited existing literature, one should be cognizant of the fact that the findings need further verification through studies with larger sample-sizes in order to increase the validity of the findings.

Radiography is used across a multitude of industries, not only in the medical field. Other industries with radiological applications include the security industry, research, geology, aerospace, oil, and several manufacturing industries such as the production of semiconductors as they employ X-ray technology for non-destructive testing of the produced items. As there are several different industrial applications of X-ray, the findings presented in this study only reflects a small part of radiography and should not be attributed to other industries as for example different technical criteria and specifications are used in each respective industry.

Additionally, it is important to address the limitations in regards to what the research set out to deliver. The research is focused on identifying the drivers and barriers of resistance that can be observed in the medical radiographic industry, and to understand the inherent mechanisms and nature of the resistance. As such, the research focus is not to generate managerial advice. Nonetheless, managerial implications of the findings will be addressed in short in the conclusion.

A final limitation of the research presented herein is that the imposed time constraint impeded the possibility to conduct interviews with the end-users of the X-ray devices, e.g. medical radiographers. As such the research is confined to the device makers and thus the accuracy of these companies' conceived beliefs of what their customers (i.e., the end-users) desire in terms of functionality and technological advancements have not been researched.

4.3. Data Collection

The analysis of the research performed within the constraints of this study rely on data collected from a series of semi-structured interviews. The targets for these interviews was decided as employees at internationally operating X-ray device manufacturing companies. The selection of interviewees was made under the criteria that the employees must hold a position which requires involvement in the sales and/or procurement processes. In the following two subsections, a description of how and where these interviews were carried out will be presented.

4.3.1. Interviews

Eleven interviews were carried out by the researchers at the European Congress of Radiology[1] in Vienna, Austria. The interviews followed a semi-structured format and lasted for an average of 30 minutes and were carried out in the exhibition halls of the congress as the researchers approached different, pre-identified, target companies in their respective booths. Due to the environment of the exhibition (i.e., the noise level generated from the high number of exhibition booths and attendees), audio recording was not possible. As such, it was decided that one researcher would lead the interview while the other was responsible of taking notes. A total of 50 potential interview targets were identified ahead of the congress, based on their industry background and product portfolio, and the final selection was made based on the availability of these companies. As such, the sampling followed the notion of convenience sampling as the availability and accessibility of interview targets dictated the final sampling (Bryman & Bell, 2013).

The goal of the interviews was to obtain data in order to map out the overarching and fundamental reasons for resistance towards innovation and the proneness of the different companies in regards to early adoption of new product innovations. Additionally, the interviews served to unearth what the companies believe to be the most important aspects and criteria when evaluating a new product and in which area within X-ray they believe the potential for technological advancement is the greatest.

---

[1] The European Congress of Radiology is an annual congress and exhibition organized by the European Society of Radiology (ESR). The congress caters to companies, researchers and other actors within medical imaging and diagnostics. See appendix 1 for further information.

4.3.1.1. Interviewed Companies and Interview Venue

The interviews performed were conducted at the European Congress of Radiology (ECR) in Vienna, Austria, on the 1st - 3rd of March 2018. The decision to attend ECR and use the congress as a venue to perform the interviews was made based on the merits of the congress hosting one of the largest exhibitions in the industry of medical radiology and as such providing the researchers with a large selection of potential interview targets. The 2018 edition of the congress hosted a total of 300 exhibiting companies and more than 26,000 delegates from the industry.

As previously mentioned, a total of eleven companies were interviews in the first round of interviews, conducted at the European Congress of Radiology. The selection of the companies was made based on their respective operations, product offerings and focus areas. A total of 50 companies of interest that were to exhibit during the congress was identified in advance based on criteria discussed in the previous section. Subsequently, the list of companies was reviewed once again in order to construct a list of prioritised interview targets based on an extensive review of public company information and the respective company websites. As the research conducted in this study focus on manufacturers of X-ray devices that procure components such as detectors and X-ray tubes, fully vertical companies and conglomerates was not prioritized. The goal of the interviews was decided to be a minimum of 10 companies interviewed. The final 11 companies that were interviewed was selected from the previously mentioned priority list based on their availability for interviews during the congress. Four companies expressed a desire to remain anonymous and as such their company names and the names of the employees have been excluded.

A brief presentation of the interviewed companies follow in the table below. A more detailed presentation of each respective company is provided in Annex 1.

Table 4: Interviewed Companies

Company Name	Nationality	Years Operating in the Industry
Anonymous Company 1	Eastern Europe	27 years
Anonymous Company 2	Southern Europe	27 years
Anonymous Company 3	North America	23 years
Anonymous Company 4	Eastern Asia	4 years
GMM	Italy	66 years
Italray	Italy	44 years
Newtom	Italy	22 years
Planmed	Finland	29 years
Shimadzu Europa GmbH	Germany	122 years
Ziehm Imaging	Germany	46 years
AGFA Healthcare	Belgium	89 years

Source: Interview data

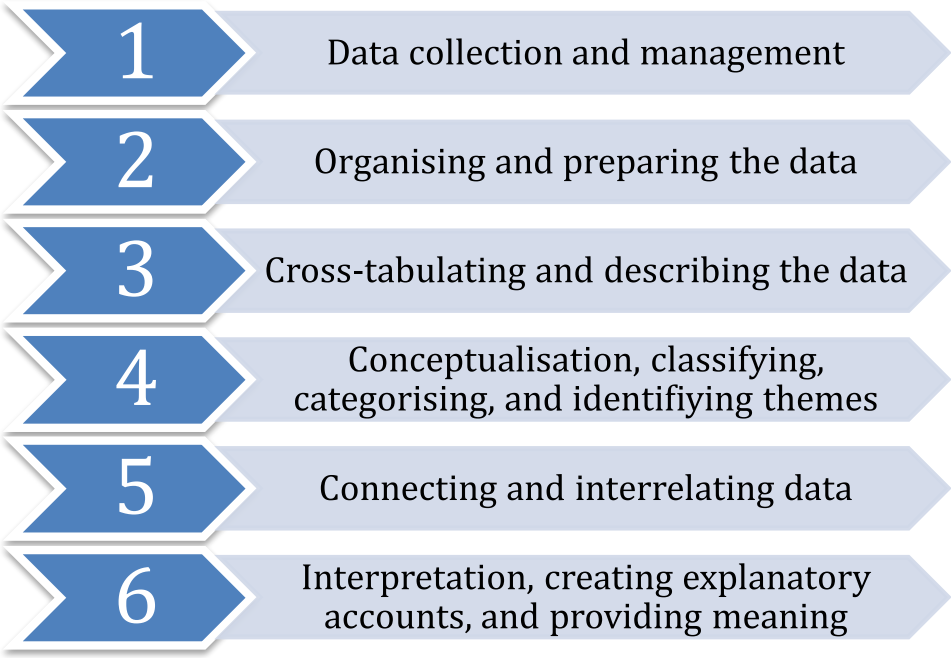
4.4. Method of Analysis

As previously discussed in prior sections, the research performed herein employ a qualitative deductive approach with comparative analysis of the data collected from a series of semi-structured interviews to the existing academic theory and literature.

The interviews have been performed with the ambition of unearthing the underlying drivers of resistance towards innovations within medical radiography with the interview guides and the interview format relying on the extensive literature review carried out.

The analysis has followed a general qualitative analysis process, with some modification due to limitations regarding the ability to record the interviews for transcription and coding. To work around the limitations, we created a set of tables of all the interviewed manufacturers and cross-tabulated with the drivers and barriers identified by the literature. Utilizing these tables, we put down notes when the manufacturers talk about subjects that can be correlated to either the drivers or barriers, thus giving us a reasonable substitute to coding transcribed interviews. This gives us a reasonable complement to notes made during the interviews.

Figure 6: Qualitative analysis process[2]



As figure 5 above illustrates, the analysis carried out began with the data collection and the management thereof facilitating a smoother process of organising and preparing the data. The data retrieved was subsequently cross-tabulated, described and categorised to facilitate the identification of underlying themes and patterns.

As the analysis utilized the concept of cross-tabulating interview data, it relied heavily on uncovering patterns and identifying themes allowing for greater comparison, thus making the interpretation of the results easier. Identifying themes and patterns and categorising and coding the data is crucial in order to discover similarities and identifying what comprises the intrinsic drivers of resistance towards innovative products within the industry on which this research focus upon.

Once the analysis of the interview data was complete, a comparison was made between findings from existing literature and that of the interviews to unearth any discrepancies and similarities.

---

[2] Based on: Analysing Interview Data, Dr Maria de Hoyos & Dr Sally-Anne Barnes Warwick Institute for Employment Research, 15 February 2012, https://warwick.ac.uk/fac/cross_fac/esrcdtc/coretrainingmodules/quals/analysing_interview_data_1_-_w6.pdf

5. Empirical Findings

5.1. Interviews Results

Representatives from a total number of 11 companies were interviewed in conjunction with European Congress of Radiology in Vienna on March 1-3 2018. The interviews were conducted using a semi-structured format, allowing the interviewees to elaborate on their thoughts without confining the discussion by limitations imposed of a firm interview schedule with specific questions. However, an interview guide with example questions were used to guide the discussion ensuring that the topic did not stray from the intended focus areas.

In the following subsections, results of the interviews will be presented. Section 5.1.1. covers adoption of microfocus, 5.1.2. customer influence, 5.1.3. component sourcing, 5.1.4., satisfaction with performance of current components, and finally section 5.1.5. covers the industry's outlook and expectations for the future.

5.1.1. Microfocus

As previously mentioned, this research focus on innovations in X-ray technology such as microfocus. As such, all interviewees were asked whether their company use microfocus technology in their medical X-ray systems today. Out of 11 respondents, none of the companies were found the be utilizing the technology. These results were expected by the researchers. However, the respondents were asked to elaborate on their companies' perceptions on the technology and why they have opted out of adopting microfocus.

As the interviewees elaborated, it became evident that all were content with image resolution obtained from focal spot sizes ranging between 0.3mm and 1.3 mm. It should be clarified that the focal spot size of microfocus tubes lies in the range of 1-100µ (µ=micron) which in millimetres would be 0.001-0.1mm. Below follow excerpts from four of the interviews.

"The image resolution gained from the current tubes is sufficiently high for medical imaging and there is thus no need for greater resolution or improvement on the component side of imaging."

Lamberto Marzzochi, General Manager at Italray

"Microfocus is not optimal for medical as a focal spot size of 0.5mm provides sufficiently high image resolution."
Anonymous Company 4

"0,6-1,0 mm focal spot, which is market standard and good enough for the intended usages of medical x-ray in terms of image resolution."
Michael Eifart, Assistant Manager, Product Marketing (Medical business unit) at Shimadzu Europe GmbH

"No need for microfocus. Additionally, switching to microfocus would require better detectors than what is currently in use in order to capture the full potential and benefits such as even higher image resolution."
Gert Merckx, Global Product Manager (Modality Workstations & Dynamic Imaging) at AGFA Healthcare

5.1.2. Customer Influence

To fully understand the intrinsic reasoning of the companies, one most understand the customer and what role they play in the company's decision making process. As this study focus on X-ray technology, the customers of the device makers are the end-users of the X-ray system doctors, surgeons, emergency responders etc.). Of the eleven interviewees, eight respondents elaborated on the extent of influence their customers have in regards to the construction and setup of their X-ray systems/devices.

Interestingly, a 50/50 split amongst the respondents was observed as four interviewees argued that their respective company is highly influenced by customer preferences while the other four respondents claimed to experience little or no customer influence.

The respondents were subsequently asked how the customer influence is exhibited. Customers were found to mostly influence the exterior design of the system and compatibility features in addition to being focused on the reliability of the device.

High Customer Influence

"Customers have a significant amount of influence as the company is very customer oriented. If a customer asks for changes the company tries to adapt the product accordingly and also offers post installation adjustments."

Luigi Perico, Product Development at General Medical Merate

"The customers have a quite large influence on Planmed in regards to the design of the device. The company prides on a customer focused approach in all aspects. However, it should be mentioned that the customers most often do not possess knowledge in regards to the technical specifications. Instead, they are more focused on the images."

Johan Moed, Sales Manager at Planmed

"Great customer influence/involvement. The customer influence primarily focus on aspects such as the compatibility of the devices in regards to the customers' workflow. Additionally, the reliability of the device and its components."

Gert Merckx, Global Product Manager (Modality Workstations & Dynamic Imaging) at AGFA Healthcare

Low Customer Influence

"Newtom experience their customers to have a small influence on the design and composition of their devices."

Simone Squarzzoni, Product Specialist at Newtom

"Customers have a small influence in regards to components used and the design of the devices."

Anonymous Company 1

"The customers have low influencing ability of the choices of components within the devices offered. Focal size of the x-ray, and the thermal by-production is often asked by customers. Continuously developing regulatory demands from supranational organization regarding safety and radiation exposure play a far greater role in the influencing of what types of components that will be used in the devices.

And as previously mentioned, the levels of commoditization of all the components within x-

ray devices, makes the market less reliant on component specifics and more focused on the value of the product as a whole."

Lamberto Marzzochi, General Manager at Italray

5.1.3. Component Sourcing

Knowing whether device makers source their components, such as the X-ray tube, from external companies or develops their own, and what relationships they have with their suppliers facilitates greater possibilities of unearthing the intrinsic drivers of resistance towards new products.

Most the companies interviewed, eight out of eleven, source their X-ray tubes from external tube manufacturers. Two of the companies produce tubes either through a collaboration with third party or in-house. One of the respondents declined to answer. Three of the companies had been using the same supplier for between 4 and 20 years, averaging around 9 years. A fourth respondent could not provide an estimation but explained that the company focus on building long-term relationships with their suppliers.

One company claimed to constantly evaluate new options in order to maximize the performance of their devices. On the other hand, another company elaborated on why they are reluctant to change suppliers.

"Hard to estimate but the company performs continuous evaluation and reflection to find new components and research progress within the market."

Michael Eifart, Assistant Manager, Product Marketing (Medical business unit) at Shimadzu Europe GmbH

"Utilizing our long-term supply network for many of their components. Due to the conservative nature of the industry, there is few reasons to change often, as change brings variability and uncertainty to the overall performance."

Martin Ringholz, Director Global Marketing at Ziehm Imaging

5.1.4. Performance Satisfaction

In general, the interviewed companies were found to be sufficiently satisfied with the performance of the components sourced and integrated into their X-ray devices. Nonetheless, five interviewees propose that improvements are sought for. The most prominently mentioned areas wherein the components can be improved was image quality, radiation dose, and overheating.

"Planmed are satisfied with the current detectors being used in their devices. However, the company believe that it is of great importance to consistently keep track of new innovations and solutions. Most importantly is advancements in regards to the photon counting technology for detectors. Planmed's devices would benefit from using the photon counting technology but for the detector size needed, the current photon counting detectors are prone to break and come at high costs making it not viable as a component today. In terms of the X-ray tubes, Planmed are satisfied with the performance. However, reducing the radiation dosage is always a priority. As such, a micro focus tube with higher image resolution would only be a viable alternative if radiation dosage could be reduced at the same time. For Planmed, the goal is to provide the best possible imaging at a low dosage."

Johan Moed, Sales Manager at Planmed

5.1.5. Future Technological Advancements in Medical Radiography

When the focus of the interview discussions shifted towards future improvements and advancements of the industry, the products and the components, the interviewees were given an open platform to present their personal beliefs and that of their companies. At this point in the discussions, some chose to focus on where they and their companies prefer that further advancements are made while others to a more general holistic approach by discussing where they believe the improvements and advancements are the most likely rather than what areas they personally prefer advancements to be made.

Of those interviewees focusing on where they and their companies prefer, or would like, advancements to be made, the most commonly mentioned area was image quality and dosage control.

“Capacity, speed is the goal for medical imaging.
Further lowering the radiation exposure with more efficient dose management. The future goal of the industry is the same as it always has been; either better images at a static radiation dosage level, or, static image quality with reduced dosage levels.”

Michael Eifart, Assistant Manager, Product Marketing (Medical business unit) at Shimadzu Europe GmbH

“...Increase image quality and decrease the dose...”

Simone Squarzzoni, Product Specialist at Newtom

“*Lower dose, maintain a good image quality*”

Martin Ringholz, Director Global Marketing at Ziehm Imaging

On the other hand, interviewees focusing on areas where advancements perhaps are most likely to be made, due to the current technological focus of the industry in general, mentioned software as the next game changer. Software for medical radiography, refers to imaging processing software and the introduction of artificial intelligence (AI).

“...the biggest advancements will most likely be on the image processing and analysing side of the industry. Digitalization is pushed heavily on the ECR 2018, and will most likely be implemented by most device makers in the close future. Other innovations that could advance the efficiency of medical imaging and processing would be the development of AI and new software. There is few to almost no technological advancements for internal technologies apparent in the near future. Much of it is due to the limitations of physics and the capabilities of a well-known technology that has mostly stayed unchanged for the last 60 years. Little room for radical innovation, and in terms of incremental improvements it is limited to physical capabilities of the materials used within the industry.”

Lamberto Marzzochi, General Manager at Italray

“The software used for image processing will definitely be what dictates the future of radiography. Further advancements can be made in order to enhance image processing and analysis.”

Luigi Perico, Product Development at General Medical Merate

6. Analysis

In section 3.3, literature review, we explained that an important reference point for individual users is the status quo as previous research have shown that there is a predicated tendency for preference of current products over innovations regardless of the higher relative advantage of said innovation (Falk, Schepers, Hammerschmidt, & Bauer, 2007). We also underlined that the tendency of customers to prefer tried and proven products when faced with an innovation and the resulting likelihood for innovation to be resisted by the intended user (Hetts, Boninger, Armor, Gleicher, & Nathanson, 2000) (Ram, 1989). Additionally, it was also noted that one must consider the perceived psychological switching costs (Garcia, Bardhi, & Friedrich, 2007).

This section will revolve around the analysis of the company interviews. What information has been extracted, what drivers and barriers are observed to be present within the industry based upon the information, the extent and implications it can have, and what the consequences of the presence of each observed driver and barrier can have upon the decision to introduce an innovation to the medical radiographic industry.

The empirical findings from the interviews (see section 5.1), shows signs of an apparent preference for status quo. Section 5.1.1, presenting a selection of answers obtained from the respondents when discussing the adoption of microfocus technology clearly indicates a widespread preference of the current state. Interestingly, when motivating why they are reluctant to adopt microfocus, several of the respondents used phrasings such as "*sufficiently good"* or "*good enough"* when explaining their preference for the currently applied radiography technology. This indubitably points to an indifference towards the relative advantage of the new microfocus technology.

The analysis will follow the structure of first analysing the observed drivers within the industry in relation to the research literature and the implications of innovation resistance of their presence. Additionally, the drivers will be analysed from the point of inherent mechanisms, passive or active resistance.

Subsequently the observed resistance barriers will be analysed, regarding their subjective thresholds to adoption, in relation to the academic research find what drivers are the source for the barriers. Additionally, there will be a short analysis regarding the modes of resistance observed among the interviewed companies towards the specific innovation of a microfocus x-ray tube.

6.1. Drivers of Resistance

Table 5: Summary of Observed Drivers in descending order of observations

Drivers	Mechanism of Resistance	Num. of Observations
Unawareness or indifference to innovation	Passive	11
Preference for status quo	Passive	10
Economic risk	Active	5
Existing usage patterns	Active	4
Physical risk	Active	4
Functional risks	Active	2
Traditions & Norms	Passive	2
Perceived switching costs	Active	1

The identified drivers exhibit different characteristics and each will be discussed below. The order of analysis will go in a descending order from the most frequently observed driving source to least observed. Focus will be given to the drivers most frequently observed. Full list of each identified driver of each respective company based upon the interviews can be found in the appendix.

'Unawareness or indifference to innovation' have in this thesis been defined as the propensity not to adopt an innovation due to either continued use of existing products or either lacking knowledge of, or having a fixed negative perception of, how the innovative can be relevant for their needs. A clear majority of the interviewees were satisfied with the image resolution provided by their current products. Nonetheless, many of the same argued that for future technological advancements of X-ray technology, increased resolution was very important. The current microfocus technology can provide customers with increased resolution, but none of the interviewed companies are using or considering the use of microfocus at the present time. Unawareness of the clinical benefits of microfocus is likely to be what have so far hindered a widespread adoption of the technology. This would imply that any company introducing a new technology for medical radiography, must consider the

degree of innovation, or technology, dissemination that must be obtained in order to mitigate the effects stemming from unawareness.

Linked to the unawareness or indifference to innovation, a '*preference for status quo'* was also observed among the interviewed companies. Preference of status quo often stems from actors' inclination to resist change and contentedness with the current situation. The preference of an unchanged situation was exhibited through the interviewed companies' inclination to keep the current system configuration and their strong belief that current resolution and other clinical benefits were satisfactory. In general, the interviewees seemed to be very much reluctant to change components, with the only commonly repeated reason for changing components being if a new supplier could deliver the same standard and functionality as current products at reduced cost, or, alternatively, improved functionality at the same cost. The strong presence of a preference for status quo, impose a big challenge for any introduction of new innovative products. Only one of the eleven interviewed companies could not be attributed with any characteristics to would imply a preference for status quo.

The observation of '*existing usage patterns'* is based on much of the same indicators as the aforementioned driver of preference for status quo. Four of the interviewees exhibited an inherent thinking that could be attributed to maintaining the course of actions and stick to the company's traditional way of acting and thinking. One interviewee, who asked to remain anonymous, noted: "We are satisfied with the current components and their performance and see no changes needed today.

Both *'economic risk'* and *'physical risk'* was observed as several companies stressed their customers' need for the company to maintaining or reducing their price level while other emphasized the importance of dose control, i.e., radiation reduction.

Other observed drivers that was not found to be as prominent as the aforementioned drivers were: *'switching costs'; 'functional risks';* and *'norms & traditions'*.

Two companies exhibited driver-characteristics that could be attributed to *'norms & traditions'*. Both companies showed clear signs of preserving their current approach to system design and to only consider innovations that would help drive the costs down in order to either reduce the price of their units or increase the margins. Of the companies argued that they would consider the new product "...if the product has at least the same standard as the currently used tube but comes at a cheaper price".

'Functional risks' as a driver of resistance was found to be present in two of the interviewed companies, discussing the potential consequences of adopting new products due to issues related to, for instance compatibility. Martin Ringholz at Ziehm Imaging noted: ".../...due to the conservative nature of the industry, there is few reasons to change often, as change brings variability and uncertainty to the overall performance".

'Switching costs' was observed as a possible driver of resistance as AGFA Healthcare representative Gert Merckx pointed out that in order to fully capture the potential benefits of microfocus technology, the company would be required to acquire new 'better' detectors: *"...switching to microfocus would require better detectors than what is currently in use in order to capture the full potential and benefits such as even higher image resolution."*

No observations of the drivers *'social risk'* and *'information overload'* were made. Although X-ray radiation can be potentially harmful if certain dosage levels are exceeded, the clinical benefits of X-ray and the lack of substitutes outweighs any potential negatives and as such social risk is not a factor that must be weighed in. As for *'Information overload'*, the results from the interviews have shown that such a driver is not present in the industry today. In fact, the very opposite seems to be true as we have previously shown that lack of information is one of the most apparent drivers of resistance currently present in the medical radiographic industry.

As can be derived from the presentation of present drivers of resistance above, both active and passive drivers are identified to be present within the industry, to varying degrees. In the literature review, we noted that passive resistance comes from 2 factors; first, users' personality-related inclinations to resist change, and secondly, the contextual and situation-specific factors that determines their satisfaction with the current technology. We also stated that as soon as resistance exceeds an adopter-specific threshold, individuals will engage in such behaviour to maintain the current status quo, in the face of pressure to change and adopt an innovation (Bagozzi & Lee, 1999). As for active rejection, we noted that his active resistance is a more deliberative form of resistance and highly dependent on innovation specific factors. It was described as a deliberative non-purchase behaviour following a negative evaluation of an innovation.

In the analysis of resistance drivers existing in the medical radiography industry, there is evidence for the presence of five active drivers and three passive. It should be noted that the two most apparent drivers among the interviewed companies were both of passive nature, namely *'unawareness or indifference to innovation'* and *'preference for status quo'*.

6.2. Resistance Barriers

Table 6: Summary of Observed Barriers in descending order of observations

Barriers	Barrier characteristics	Num. of Observations
Visibility	Functional	11
Communicability	Functional	11
Norms & Traditions	Psychological	11
Usage	Psychological	11
Information	Psychological	11
Risks	Psychological	11
Value	Functional	6
Compatibility	Functional	2
Realization	Functional	2
Trialability	Functional	1
Co-dependence	Functional	1
Amenability	Functional	1

From the result of the interviews we can observe that not all barriers are identified to be present among the interviewed companies, also that the barriers observed among the companies have individual, but qualitatively undefined thresholds and impact upon the propensity and willingness to adopt an innovation for their devices. The order of analysis will go in a descending order from the most frequently observed factor to the least observed factors. A list of observed barriers for each respective company based upon the conducted interviews can be found in the appendix.

‘Visibility’ is defined by the academic literature as a barrier that concerns the targets ease or difficulty to observe the usage and functionality of an innovation. It is classified as a barrier that originates from, and is a function of, the innovation-specific functional characteristics of an innovation. Additionally, the visibility is closely related to the barrier of *trialability*, as being able to observe and test the attributes of an innovation yourself, will have a high impact on the accuracy of the perceived benefits or drawbacks of the innovation. And thus, consequently is, a direct link to the targets probability of adopting the innovation or not. For the case of our study this means that, the easier it would be for a company within the industry to be able to observe the functionality of the innovation, the easier it would be for the industry to make an appropriate evaluation of the product, henceforth either raising or lowering the resistance barrier depending on the result of the evaluation.

All of the interviewed companies can be observed to be creating resistance barriers in regard to the ‘visibility’ of microfocus x-ray tubes, as they comment that there are no observable competitive alternatives to conventional x-ray tubes available in the medical radiographic industry. And thus, no observable alternatives to evaluate the actual functionality of the product, and have to rely on their current perceptions regarding microfocus technology from the currently available information. The high rates of visibility barriers observed can be a reason for the lower rates of observed barriers concerning innovation-specific factors. The barriers might be present, but due to the high barrier of visibility, among others, they are not identifiable.

This inability to accurately observe the functions of the product, and thus not able to properly evaluate it, would likely result in the creation of a moderate to high resistance barrier among the companies interviewed in the industry, and can considered to be hold at a consistent threshold level among the companies with little deviation between the more innovation focused companies such as, Ziehm and Planmed, and the more economically focused companies of Italray and Anonymous company 2. This is due to the general lack of knowledge available and observable information creates an industrial perception that there might be uncertainties and risks related to the use of the innovation not currently known. Hence, creating a resistance barrier to adopt.

The small difference in attitude between Ziehm and Italray towards an innovation with low levels of visibility, is an interesting difference of business focus of the companies, showing that a more innovation-focused manufacturer position itself as more willing to explore and consider the options to a greater extent than a manufacturer more focused on the cost margins. Even when the product is defined by low levels of visibility.

The main drivers for the creation of a resistance barrier of 'visibility' can be linked to the companies being *'unaware of or indifferent to innovation'*, as not seeing to where they might find the relevant information and thus lowering the companies' ability to make accurate observations and evaluations.

The second most observed resistance barrier among the interviewed companies is 'communicability', which concerns the perceived difficulty to convey and disseminate the benefits of usage of the innovation to the target market. This barrier originates from the ability to convey tangible information of both innovation-specific functional and psychological features and benefits, and to reduce user-specific concerns regarding perceived risks and conflicts with current behavioural patterns. Linking this barrier to the analysis of resistance to innovation within the medical radiographic industry, it can be defined as the ability of the manufacturer of the innovation to convey relevant information to the target device manufacturers in a tangible way to lower the resistance as much. And additionally, be careful to not provide too much unwarranted information, as it would create the obverse effect *information* overload, and instead create more resistance.

Out of the interviewed companies, all of them can be classified as expressing uncertainty regarding the possible usage of microfocus x-ray within the field of medical analysis and resistance to microfocus x-ray technology based on the little or no communicated information of the technological benefits currently available to the industry. As several of the interviewed companies points towards that the sufficient performance of current conventional x-ray tubes is sufficient, makes it an argument that the manufacturers of microfocus x-ray tubes have failed to sufficiently inform current device manufacturers of the proposed benefits of switching to a newer technology.

'Communicability' can be placed in the group of resistance barriers as visibility, information and trialability, much due to the similar interdependence on the same drivers. These barriers all depend on the current perceptions and availability of the innovation to be present, and less availability of relevant information and data, the more prone are the target manufacturers to create high resistance barriers to adoption.

‘Norms & Traditions’, the third most apparent barrier observed, is a psychological barrier the according to literature occurs when there is a perception of conflict between an innovation and values of the users group, society and family. The greater the perceived conflict is, the higher becomes the resistance to the innovation. The barrier relates to the resistance drivers *‘norms & traditions’* and *‘existing usage patterns’* which both have been shown to be existing in the industry, to a limited extent (see section 5.1). Several of the interviewed companies indicated that they prefer to build long-term relationships with their suppliers which could indicate a propensity to stick to traditions and existing usage patterns rather than risking variability and inconsistencies when changing supplier.

‘Usage’, another observed psychological barrier, was in the literature review defined as a barrier “related to compatibility, and perceived usage pattern inconsistency...” where “...usage of an innovation with past experience, can disrupt user patterns and create barriers”. The larger the discrepancy is, the higher barrier becomes. Usage as a barrier is related to the drivers *‘preference for status quo’, ‘traditions & norms’* and *‘existing usage patterns’*. As such, the ‘usage’ barrier could be said to also relate to the aforementioned barrier of norms & traditions.

‘Information’, the fourth most observed barrier, is a psychological barrier stemming from information asymmetries which in turn creates uncertainty regarding benefits and risks. As for microfocus technology, this is very much the case as none of the companies interviewed have adopted the technology when at the same time the majority of interviewees argue that they would like to see increase image resolution and reduced dosage of radiation as microfocus allows for higher resolution and the potential of reduced dosage, information asymmetry is almost certainly existing. This barrier is closely linked to that of communicability and implies that companies producing microfocus X-ray tubes, and other protagonists of the technology, have as of yet failed to provide effective dissemination of the technology. The barrier of information, is related to the resistance drivers *‘unawareness or indifference to innovation’* and to varying extent the different risk related drivers. Microfocus producers seem to have failed in mitigating the perceived risks and uncertainties revolving around the efficacy and benefits of the product.

As with information, the fifth most observed barrier, Risks, is a psychological resistance barrier related to the different risk related drivers of resistance. Risk related resistance barriers are raised due to system manufacturers perceived risks or uncertainties regarding functional; improper or unreliable, physical; harmful to use, economic; low economic value to use, and social; repeated use is disapproved by relevant social groups.

‘Value’, a functional barrier, was the sixth most observed barrier and relates to perceptions regarding the relative advantage of the product, i.e., the value of use compared to existing alternatives. Higher relative advantages result in a lowered resistance. This barrier relates to the resistance drivers *‘perceived switching costs’* and *‘preference of status quo’*. Many of the interviews expressed relative advantage to be a critical factor when evaluating a potential new product. For example, four companies stressed that a new product would only be considered if the image resolution and standard of the tube was maintained while the radiation dosage and/or energy consumption was significantly reduced. AGFA Healthcare underlined that for energy consumption to be a viable deciding factor, it would have to be reduced by 30%.

Some resistance barriers identified by the literature were observed to have less relevance or at least fewer mentions among the interviewed companies, these were the functional barriers *compatibility, realization, trialability, co-dependence* and *amenability*. Where the resistance barriers were observed, they can be assumed to affect each company to a varying degree and with less consistency than the group of barriers present among all interviewed companies.

‘Compatibility’ refers to the ease of an innovation to be integrated into existing products or usage patterns of a user. The higher the compatibility, the lower the resistance barrier. Relating this to our study, it would imply that if the microfocus x-ray innovation would be able to function with the same machinery and components as current x-ray tubes, they could be considered highly compatible and more likely to be considered for evaluation. Of the eleven interviewed companies, only two mentioned an importance for innovation to be compatible with the current devices available. One reason for this is to reduce the costs of developing a new machine to house the tube, and to instead just use the x-ray tube as an interchangeable component, switchable depending on the needs of the end-user. The second reason for compatibility, and the lack thereof could hinder adoption, would be the need to produce high performance devices with high compatibility between design and function. And thus, all components have a requirement to be close to fully interchangeable and compatible. Resistance barriers raised due to a lack of compatibility can be sourced from the resistance drivers relating to *risks, perceived switching costs, existing usage patterns* and *traditions and norms*. Thus, the functional barrier of compatibility can be seen to be influenced by several drivers of both active and passive nature. Even though several other companies may have been observed to identify the aforementioned as drivers of resistance, only two explicitly mentioned the lack of compatibility as a resistance barrier to adoption of an innovation.

The *Realization* barrier is a functional barrier dependent on how short or how long an adopter of an innovation can be expected to wait until the benefits of switching products can be realized. A longer rate of realization would thus, imply a larger innovation resistance threshold. And in obverse, if the realization rate is short, the lower innovation resistance threshold. The realization rate of a functional microfocus x-ray tube applicable for medical purposes within the radiographic industry, can be defined as long, due to the product is currently still in the development stages, and as such, not readily available for either testing or large-scale purchases. In our sample of eleven interviewed device-manufacturers, there were only two companies observed to express terms that could be related to the realization rate of the innovation, AGFA Healthcare and Ziehm Imaging. In both interviews the realization concerned how far in the development process the innovation has proceeded, and the expected final date to produce a functional tube. The maturity of the innovation and time until the realized product is available can thus be identified and applied as a concern for some companies within the industry.

The realization of an innovation can be seen to derive in part from active drivers such as *economic risk* and *perceived switching costs*. This is due to a longer realization of an innovation implies a costlier venture of testing and evaluating in terms of resources and time. A more “finished” and “ready” product would be lowering the resistance barrier for the involved companies.

Trialability is a functional barrier concerning the ability of the targets of an innovation to test and evaluate the innovation before adoption or not and is closely related to perceived risks. The lower the trialability, the higher the barrier, as device-makers cannot test the functionality of the innovation, the perceived risks and uncertainties remain, and is likely to create resistance barriers. The trialability is can be sourced to active drivers following an evaluation of innovation-specific factors. Among the drivers affecting the trialability is the perceived risks before and after an innovation evaluation, but also the perceived switching costs that would be accrued with a continued usage of the innovation over the previous product. Connected to the study of this thesis, it would be implied that the trialability of the specific innovation can be regarded as very low, and likely to create high resistance barriers. We only observe one device-manufacturer explicitly concerning the trialability of the product, Ziehm Imaging, much due to the limited access to information regarding the innovation in the first place, making many companies reluctant to express any interest at all. This is most likely due to the high rates of observed visibility barriers, making the barrier of trialability not generally identifiable due to preceding barriers limiting the exposure to the innovation.

'Co-dependence' is a functional barrier related to the user's perception of dependence on complementary products for optimal innovation functionality. Although new complementary products are not required in order to increase image resolution by adopting microfocus technology, a better detector could be required for some device manufacturers if they wish to capture the full potential benefits of the technology, depending on what detector they are currently using. AGFA Healthcare stressed this by stating that "...switching to microfocus would require better detectors than what is currently in use in order to capture the full potential and benefits...".

'Amenability', a functional barrier, in this case, observed only in one of the interviews performed with a device manufacturer targeting the low to mid-price segment, relates to the ability to customize and modify the innovation in order to improve user fit and satisfaction. Low levels of amenability lead to high resistance or rejection. In the interview sample, the desire for ability to customize the product mainly relates to factors of products size and portability.

Two barriers identified in the literature were not observed in the industry, 'Image' and 'Complexity'. 'Image' is related to negative perceptions of brand, industry and/or country of origin while 'Complexity' revolves around the complexity of the technology and the complexity to use the product. Not one of the companies indicated that brand perception influenced their decision making and product evaluation. On the contrary, Italray stated that “the components today are highly commoditized and there is little variation and high compatibility with many different components and devices. Components with the technical specifications you need for each respective device are easily accessible". As for ‘Complexity’, the same statement can be used to underline that although an X-ray tube might seem complex for a layman, the design and functionality of tubes have remained more or less unchanged for many decades, which we discussed in the early sections of this thesis. As such, the X-ray tube could not be attributed as being a complex product for the interviewed companies or market. Thus, the non-existence of a ‘Complexity’ barrier in our sample is unsurprising.

In the analysis of resistance barriers within the medical radiographic industry, six barriers can be identified to be present among the interviewed companies, four psychological, and two functional. The identified barriers concern the lack of relevant information and ability to observe the benefits of the innovation in use. Thus, creating many uncertainties related to innovation-specific factors. The presence of barriers relating to information dissemination creates an uncertainty regarding the apparent lack of barriers related to functional factors within the industry. Showing a propensity to resist the innovation before a product evaluation can be made.

6.3. Modes of Resistance

In accordance to the previous literature (Szmigin & Foxall, 1998) (Laukkanen, Sinkkonen, & Laukkanen, 2008) & (Kleijnen, Lee, & Wetzels, 2009) an analysis of the empirical findings from a perspective of observed modes of resistance within the industry is also conducted. It will serve as an indicator for consumer-attitude to the specific innovation. Depending on the mode of resistance observed among the consumer, different strategies will be required for innovation success.

Based on the information of the interviews, and the observed drivers of resistance and barriers, there is only minor variation of the observed modes of resistance between the interviewed companies. Depending on the company attitude to innovation and business model, they are observed to exhibit a form of resistance most similar to either, *Rejection* or *Postponement*. Several companies exhibit a mix of indicators of each mode of resistance but not enough information was made available to make a more conclusive and assertive categorization of the companies.

The analysis will primarily focus on the companies that could clearly be categorized. The result and inconclusiveness of the mode of resistance analysis will be further addressed in the discussion section.

6.3.1. Postponement

The primary companies that are observed to mainly exhibit a postponing attitude towards the use of microfocus x-ray within the medical radiographic industry are: AGFA Healthcare, Ziehm Imaging & Shimadzu Europa GmbH. Based upon their attitudes and willingness to consider the benefits of innovation, but showing some constraints due to the limited information and uncertainties regarding the innovation. This can be concluded to be a disregard for the innovation in terms of innovation-specific factors such as design and complementary assets, and the innovation is likely to not be considered until these risks or uncertainties can be properly resolved. As in the case of AGFA, it can be found to be based upon their stance that the full benefits of introducing microfocus can only be captured if the complementary assets, in this case detectors, can be exchanged for more technologically advanced components. In the case of Ziehm, they are observed to be open to innovation, but are seen to be hesitant until a proof of concept for medical radiography is available, and concerns about potential innovation-specific compatibility issues, such as design fit, needs to be addressed to encourage innovation adoption. Additionally, Shimadzu Europe is observed to exhibit an organizational attitude towards innovation that can be can be partially attributed to the postponement-mode. This is made evident by Shimadzu’s process of reviewing the market, available technology and research progress, using a continuous and procedural evaluation process. As such, the company is postponing an adoption decision until it can be deemed as satisfactory for their needs. Much akin the process of evaluating an innovation once more information is available presented in the literature.

6.3.2. Rejection

There is one company that can be observed to primarily exhibit the characteristics of rejecting innovation, Italray. When discussing components such as the X-ray tubes and the detectors, the company took a firm stance against adoption and the usability of the innovation by implying that all components are highly commoditized. Furthermore, they perceive that there are no further possible technological advancements to make within the field of radiographic industry, at the present moment due to the limitations of physics. The company is shown to reject the innovation mostly based on their perceived risks and uncertainties with the functionality of the innovation, but also due to their current position within the industry, utilizing mature technologies, largely unchanged in principle for the last decades, showing preference or satisfaction with current technologies and components.

Additionally, anonymous company 2 & anonymous company 4 are also observed to exhibit partial or hesitant rejection, although not outright rejecting, and state that they would require a provable significant relative advantage over current products to consider adoption, based on the interview result. The partial rejection can be attributed to the uncertain value proposition of switching from satisfactory components to unproven innovation, or the perceived unsuitability of the technology and applicability within the field of medical imaging. Thus, not postponing the adoption of the idea, but rejecting the innovation until a proof of concept can be presented.

No definite observations of attitude towards innovation could be attributed to the resistance mode of opposition have been made. None of the interviewed companies can be viewed as decisive opposing the innovation of microfocus. However, many of the companies argue that adopting microfocus for the sake of increased image resolution is not a priority and that other technical improvements would be required for them to consider switching their current tubes for a new microfocus tube. As such, they are open to adopting new products but are resistant towards microfocus due to uncertainties and risk.

From the results and the analysis, the customer resistance to the innovation of microfocus within the medical radiographic industry can be observed to primarily stem from passive innovation-specific drivers, mainly relating to the dissemination of relevant information. The barriers created among the customers concerns the yet unobserved or perceived uncertainties and risks related to the functions of the technology i.e., psychological barriers, and the customer resistance manifests to varying degrees from postponement to rejection, showing hesitation or unwillingness to evaluate until more information is available.

7. Discussion

Through cross-referencing the analysis performed in the previous section with the research questions as defined in section 1.4, some conclusions can be made in regards to the characteristics of the medical radiography industry in general. These insights can also in turn provide proposals of future research topics.

> *RQ1: What sources of resistance drives the device manufacturers' resistance to microfocus in the medical radiographic industry?*

Academic literature focused on innovation resistance and its characteristics and mechanisms have been used to define a set of universal resistance barriers and the drivers and resistance modes thereof (see table 2 and 3). These are however general for the modern global economy and may or may not be applicable to different specific industries. The analysis of the data collected through the literature review and the interviews conducted have shown that the medical radiographic industry may be viewed as a rather conservative field wherein established preference for status quo and current functionality of x-ray technology have a perceived dominating influence on business decisions and the shaping of the industry in its entirety. Additionally, a scarcity of information on new technologies and its benefits for the industry seem to play a large role in driving innovation resistance. In any given industry with high levels of competition, benefits of a new product must be weighed against the costs and risks of adoption. When there is a lack of information available on how a new technology can offer a relative advantage, the risk and uncertainties increase, especially if it will increase the cost of goods sold, and companies may thus become reserved and resist the innovation. This is no less true for a conservative industry such as medical radiography.

In the analysis, the drivers of resistance observed during the interviews were presented along with a short discussion on how these are manifested. In total, eight different drivers were identified. The most apparent drivers identified were: *'unawareness of, or indifference to, innovation'* and *'preference for status quo'*. These two drivers are both, in the literature, classified as being of a passive nature. In section 3.3.6.1., passive resistance was described as based on psychological characteristics and behaviour triggered by change (Bagozzi & Lee, 1999). This fear of losing control and the emotional attachment to status quo, was argued to have a propensity to result in "discouraging consumers from actively dealing with new products” and that this disinterest towards alternatives develops innovation resistance (Talke & Heidenreich, 2013).

The psychological characteristics of passive resistance implies that the device makers in the medical radiographic industry rejects, or postpones adoption of, microfocus technology not based on its technical merits and functionality but instead due to perceived uncertainties and risks coupled with the innovation. An important addition to the discussion of identified drivers within the industry is that the apparent dominant presence of passive resistance drivers among the device manufacturers does not exclude the possibility of a presence of active resistance drivers other than what is observed among the interviewed companies. It can be argued that the identified sources of passive resistance among the device-manufacturers are too great at the current moment and have such impact that a proper identification of possible active drivers may not be possible. Talke & Heidenreich (2013) argue that if the passive resistance is too high, further consideration and evaluation of active resistance drivers and barriers will not be possible. The result of the interviews show a similar conclusion, as there are too many uncertainties and unknown variables for an analysis in regards to the functionality to be viable.

> *RQ2: What resistance barriers are identified amongst device manufacturers within the industry?*

The analysis section demonstrated that there are six barriers which are highly prevalent in the industry as each of the eleven companies interview exhibited characteristics that can be attributed to each respective barrier. Four of these barriers, namely ‘Visibility’, ‘Communicability’, ‘Usage’ and ‘Information’, may be interpreted as being related to the dissemination of the innovation. The remaining two barriers, ‘Norms & Traditions’ and ‘Risks’ may be viewed as more related to the behavioural characteristics of the companies and the industry altogether. The barriers identified are shown to exhibit both functional and psychological characteristics, with emphasis on the latter category. This implies that there are barriers to adoption reliant on both innovation specific and situation specific characteristics. Mostly relating to the lack of exposure to innovation-specific information that would help the target customers to do preliminary product evaluations.

The observed barriers, are put in relation to the observed resistance drivers. Although several drivers of resistance, all contributing to the construction of barriers, have been observed in the interviews, most of the resistance seem to stem from *'unawareness of, or indifference to, innovation'* and *'preference for status quo'*. As for the barriers, these drivers may also be interpreted as related to dissemination of the innovation and behavioural characteristics with *'unawareness of, or indifference to, innovation'* being related to the former and *'preference for status quo'* analogous to the latter.

In regards to the dissemination of the innovation, the response from all interviewed companies is rather unanimous in terms of their understanding of the innovation and its clinical benefits. An apparent lack of information has been observed amongst all companies as not one see any feasibility for the innovation at the present moment when referencing the technology in general terms. There is a potential lack of understanding of exactly how the technology could be used to improve their product portfolios and offerings. This information discrepancy was made abundantly clear as several companies, when asked to expand on their thoughts on desired technological advancements, raised image resolution and quality as one important area for improvement. Yet one other area for which there was a clear desire for improvement was the radiation dosage levels. As have been previously discussed in this thesis, the technology of microfocus X-ray does indeed promise both increased resolution and overall quality of the images as well as the potential for decreased dose levels. As such, the questions then are why microfocus have not been adopted by the industry as of now and why the industry seems to exhibit resistance towards the innovation. One reason for this might simply be a lack, or poor quality, of innovation dissemination on the part of microfocus technology manufacturers.

In section 2.2.3., examples of studies proving the clinical benefits of the technology was presented in short. Nonetheless, it seems as these studies have failed to reach a wide audience. In combination with poor dissemination efforts from companies developing microfocus solutions, this may be on crucial reason for the lack of adoption. Another reason may also be that the conservative nature of the medical radiographic industry has indirectly affected said companies. The lack of understanding in regards to microfocus technology amongst device makers in medical radiography may as such stem from lack of communication from the companies developing the technology whom in turn seem to have been focused on other, industrial, applications of X-ray.

The other main driver observed, *'preference for status quo'*, fuels the barriers of 'Norms & Traditions' and 'Risks'. Most the companies interviewed exhibited a number of conservative characteristics with some even outright describing the industry as conservative and the products to be highly commoditized and lacking significant component differentiation. In the previous section, this driver was defined as the propensity to resist change. This propensity was indicated by several of the discussions points during the interviews. The analysis showed that a substantial number of the interviewees preferred long-term relationships with suppliers and downplayed the need for continuous supplier evaluation. This may be a symptom of a preference toward existing usage patterns and an inclination to avoid risks that could be derived from variability and inconsistencies. Many of the companies nurtured a desire to maintain the current system configuration, arguing that the current setup is providing sufficient quality and results. Most interviewees were found to be reluctant to change components, arguing that a change in supplier and/or components would only be of interest if the product delivered the same standards and merits as those of the currently used while coming at a reduced price.

Four of the six barriers, that were found to be dominant in the industry, are characterized as psychological barriers as defined in section 3.3.4. Psychological barriers originate from perceived usage clashes with traditions and norms and perceptions regarding the product image, related to the market, industry image and country of origin (Ram & Sheth, 1989). These barriers are highly dependent on individual-specific characteristics and the situational context. As previously mentioned, the observed drivers that creates the barriers of resistance have also been found to be of a psychological nature. As such, the findings from the interviews and the subsequent analysis indicates that the drivers of resistance seem to be originating from situational or contextual factors rather than individual or innovation specific factors. This could be argued as the results have signalled a lack of understanding and lack of information of microfocus technology as the respondents seem to desire the inherent benefits provided by the technology but fail to see how these can be derived from said technology. As such, the resistance observed does not seem to be specific to the innovation per sé but rather reveals an information asymmetry.

The resistance towards microfocus is seemingly exhibited through different resistance modes, namely 'rejection' and 'postponement'. As pointed out in the analysis, no oppositions in its purest form was observed. It should be stressed, that many of the companies exhibited a mixture of ‘rejection’ and ‘postponement’ and, as will be discussed further, strictly categorizing the respondents into either mode could prove more damaging than fruitful for understanding the complexity of the topic and the industry. Nonetheless, not drawing clear lines makes the application of current theories regarding modes of resistance more difficult.

As discussed in the analysis of the empirical findings, three companies, Italray, Anonymous company 2 and Anonymous company 4, were observed to exhibit partial or hesitant rejection. None of these companies are outright rejecting microfocus technology but they are nonetheless expressing objections towards adoption as they perceive the technology to be unsuitable for medical applications. In order to increase their willingness to adopt microfocus, a significant relative advantage of the technology over currently used products must be proven. Additionally, the three companies express a desire for other areas of X-ray to be improved rather than image resolution and as such, microfocus X-ray tubes would not be considered for adoption based solely on the improved image quality that can be derived from it.

Postponement have previously in this thesis been described as a mode of resistance in which the customers (in this case the device makers) delay, or *postpone*, adoption of innovations due to perceived risks and uncertainties although they in some cases understand the innovation’s relative advantage in functionality. More often than not, postponement relates to active resistance and innovation specific factors. Some of the interviewed companies, such as AGFA Healthcare, Ziehm Imaging, and Shimadzu Europa, have expressed positive attitudes towards innovation and willingness to consider its benefits. Nonetheless, these companies are, for the time being, restraining from adoption until perceived risk and uncertainties are resolved. In the analysis, it was noted that AGFA Healthcare is postponing adoption as they believe other components would need to be changed as well in order to reap the full benefits of microfocus technology. Ziehm Imaging and Shimadzu Europa, on the other hand, are seen to be hesitant until a proof of concept for medical radiography is available and concerns about potential, innovation-specific, product compatibility issues have been resolved.

As previously mentioned, no outright opposition to innovation was observed amongst the respondents. However, a small number of companies exhibited a few characteristics, as well as made some specific statements, that could be attributed to, or develop into, the opposition mode. This does not imply that these companies should be considered as opposers, rather it underlines that many of the interviewed companies exhibits a mixture of attributes and characteristics and as such can be grouped into at least two separate modes of resistance. One example of this is Italray. In the analysis, it was concluded that the company have so far rejected the innovation of microfocus technology based on their perceived risks and uncertainties of the innovation. Additionally, the company exhibited a preference for a technological status quo, utilizing mature technologies rather than searching for new and improved alternatives. The company also stated that they believe the room for innovation to be very limited as X-ray after all relies on physics and as such technological advancements is constrained by the very nature of physics. Nonetheless, the company still desire improvements in most areas, but fail to see how this could be achieved given the mentioned constraints of X-ray. As such, their stance towards microfocus and innovation in general within the sector, displays signs of both rejection and opposition.

8. Conclusion and Implications

The thesis set out to identify the sources and barriers of innovation resistance among device manufacturers within the medical radiographic industry, using theories established by previous researchers in a specific industrial setting. The empirics is a result of a set of conducted interviews with industrial actors. The result of the analysis shows that there is resistance towards innovation present in the medical radiographic industry. The barriers identified among the device makers are shown to primarily concern psychological factors, regarding customer behaviour and perceptions, stemming from passive resistance drivers relating to the present lack of information, knowledge and understanding of the innovation as well as perceived risks and uncertainties. The results indicate an industrial preference for the status quo, and a need for future innovation information and evaluation before considering for adoption. Additionally, the modes of resistance among the device manufacturers can be identified as variations between postponing and rejecting the innovation, based upon the current perceptions of risks and benefits of usage, and company profile.

In short, the medical radiographic industry is shown to create resistance barriers based on the current lack of relevant information, and will postpone or reject the adoption until a significant relative advantage in usage can be proven.

With a focus on the case of a specific innovation within a specific industry, interpreting the results of the research as applicable for all types of innovation within this specific industry or others is not suitable. Nonetheless, the findings from the research shed light on the conservative nature of the medical radiographic industry and the apparent widespread preference for maintaining the technological status quo.

8.1. Managerial Implications

The result of the research shows that a company aiming to introduce an innovation to the medical radiographic industry will need to efficiently disseminate appropriate information, and address the customers' concerns regarding innovation-specific factors, and amend if possible, for a larger chance at a successful innovation introduction.

The conservative nature of the industry translates to a great need for proof-of-concept and clear communication of the potential benefits of the product. Moreover, the research has found that companies in the industry are reluctant to change suppliers and/or to evaluate new product alternatives. As such, management must put emphasis on marketing efforts to resolve the customers perceived risks and uncertainties through clear and precise market communication.

8.2. Future Research

The industry and innovation specific outcomes of this research can serve as inspiration for future research for investigating consumer influence, and industrial mode of resistance to innovation in general. For the medical radiographic industry, this research has shed light on its conservative nature and more extensive research into how the social behaviour of the companies is affected by external factors could be of interest. An end-user oriented research, investigating the opinions, needs and desires of medical radiographers could increase the understanding of the industry. Even more so as this research have found customer influence to be considered as secondary by many actors. Thus, research in regards to the relationship of device-makers and end-user would be of interest.

List of References

Antioco, M., & Kleijnen, M. (2010). Consumer adoption of technological innovations: Effects of psychological and functional barriers in a lack of content versus a presence of content situation. *European Journal of Marketing*, 1700-1724.

Bagozzi, R. P., & Lee, K.-H. (1999). Consumer Resistance to, and Acceptance of, Innovations. *Advances in Consumer Research*, 218-225.

Buckland-Wright, J.C. (1976). The micro-focal X-ray unit and its application to bio-medical research. *Experientia*. 32:1613. https://doi.org/10.1007/BF01924484.

Buckland-Wright, J.C. (1989) A new high-definition microfocal X-ray unit. *The British Journal of Radiology*, Vol.62(735), pp. 201–208

Buckland-Wright, J.C. & Bradshaw, C.R. (1989). Clinical applications of high-definition microfocal radiography. *The British Journal of Radiology*, Vol.62(735), pp. 209–217

Bryman, A., & Bell, E. (2013). Företagsekonomiska forskningsmetoder (2., [rev.] uppl. ed.). Stockholm: Liber.

Claudy, M. C., Garcia, R., & O'Driscoll, A. (2015). Consumer resistance to innovation - a behavioural reasoning perspective. *Journal of the Academy of Marketing Science*, 528-544.

Cosslett, V. E. & Nixon, W. C. (1951). X-Ray Shadow Microscope. *Nature*, 168(4262), 24-5.

Cox, D., & Cox, A. (2002). Beyond first impressions: The effects of repeated exposure on consumer liking of visually complex and simple product designs. *Journal of the Academy of Marketing Science*, 119-130.

Davidson, R. S., & Walley, P. B. (1985). Computer fear and addiction: Analysis, prevention and possible modification. *Journal of Organizational Behavior Management*, 37-51.

Demircin G, Oner A, Ecin N, Bülbül M, Somuncu I, Tunali H. (1998). Microfocal radiography in the diagnosis of childhood renal osteodystrophy. *Acta Paediatr Jpn*. Oct;40(5):461-5.

Dhebar, A. (1996). Speeding high-tech producer, meeting the balking customer. *MIT Sloan Management Review*, 37-49.

Dholakia, U. M. (2001). A motivational process model of product involvement and consumer risk perception. *European Journal of Marketing*, 1340-1362.

Ellen, P. S., Bearden, W. O., & Sharma, S. (1991). Resistance to Technological Innovations: An Examination of the Role of Self-Efficacy and Performance Satisfaction. *Journal of the Academy of Marketing Science*, 297-307.

Fain, D., & Roberts, M. (1997). Technology vs. consumer behaviour: The battle for the financial service customer. *Journal of Interactive Marketing*, 44-54.

Falk, T., Schepers, J., Hammerschmidt, M., & Bauer, H. H. (2007). Identifying Cross-Channel Dissynergies for Multichannel Providers. *Journal of Service Research*, 143-160.

Gabiere, P., Chern, W., Hahn, D., & Chiang, F.-S. (2004). Consumer Attitudes towards genetically modified foods in emerging markets: The impact of labelling in Taiwan. *International Food and Agribusiness Management Review*, 1-20.

Garcia, R., Bardhi, F., & Friedrich, C. (2007). Overcoming Consumer Resistance to Innovation. *MIT Sloan Management Review*.

Gatignon, H., & Robertson, T. S. (1989). Technology diffusion: An empirical test of competitive effects. *Journal of Marketing*, 35-49.

Greenleaf, E. A., & Lehmann, D. R. (1995). Reasons for substantial delay in consumer decision making. *Journal of Consumer Research*, 186-199.

Herbig, P. A., & Day, R. L. (1992). Customer Acceptance: The Key to successful Introductions of Innovations. *Market Intelligence & Planning*, 4-15.

Hetts, J. J., Boninger, D. S., Armor, D. A., Gleicher, F., & Nathanson, A. (2000). The influence of anticipated counterfactual regret on behaviour. *Psychology & Marketing*, 345-368.

Kleijnen, M., Lee, N., & Wetzels, M. (2009). An exploration of consumer resistance to innovation and its antecedents. *Journal of Economic Psychology*, 344-357.

Labrecque, J. S., Wood, W., Neal, D. T., & Harrington, N. (2017). Habit slips: when consumers unintentionally resist new products. *Journal of the Academy of Marketing Science*, 119-133.

Laukkanen, P., Sinkkonen, S., & Laukkanen, T. (2008). Consumer resistance to internet banking: postponers, opponents and rejectors. *International Journal of Bank Marketing*, 440-455.

Lee, Y., & O'Connor, G. (2003). New product launch strategy for network effects products. *Journal of the Academy of Marketing Science*, 241-255.

Moore, G. C., & Benbasat, I. (1991). Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation. *Information Systems Research*, 192-222.

Nabih, M. I., Bloem, S. G., & Poiesz, T. B. (1997). Conceptual Issues in the Study of Innovation Adoption Behavior. *Advances in Consumer Research*, 190-196.

Nascimento, M. (2014). Brief history of X-ray tube patents. *World Patent Information, 37*(C), 48-53.

Parish, R. W. (1986). Microfocus x-ray technology -- a review of developments and application. *Review of Progress in Quantitative NDE*. Vol 5A, pp. 1–20

Post, K., Hermann, KP., Funke, M. et al. (1997). Direktradiographische Vergrößerungsmammographie mit einer neuen Mikrofokusröhre (GER). *Radiologe*. 37: 604-609.

Ram, S. (1987). A model of innovation resistance. *Advances in Consumer Research*.

Ram, S. (1989). Successful Innovation Using Strategies to Reduce Consumer Resistance: An Empirical Test. *Journal of Product Innovation Management*, 20-34.

Ram, S., & Sheth, J. N. (1989). Consumer Resistance to Innovations: The Marketing Problem and Its Solutions. *The Journal of Consumer Marketing*, 5-14.

Rhoda, J. (2010). Individual resistance to IT innovation. *Communications of the ACM*, 144-146.

Rogers, E. (1995). Diffusion of innovations (4th ed.). *New York: Free Press*.

Schein, E. H. (2010). *Organizational Culture and Leadership (4th edition).* Wiley.

Stone, R. N., & Grønhaug, K. (1993). Perceived Risk: Further Considerations for the Marketing Discipline. *European Journal of Marketing*, 39-50.

Straub, E. T. (2009). Understanding Technology Adoption: Theory and Future Direction for Informal Learning. *Review of Educational Research*, 625-649.

Szmigin, I., & Foxall, G. (1998). Three forms of innovation resistance: the case of retail payment methods. *Technovation*, 459-468.

Talke, K., & Heidenreich, S. (2013). How to Overcome Pro-Change Bias: Incorporating Passive and Active Innovation Resistance in Innovation Decision Models. *Journal of Product Innovation Management*, 894-907.

Venkatesh, V., & Davis, F. D. (2000). A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science, Vol. 46*, 186-204.

Weavers, et. al. (1993). Application of microfocus X-ray radiography in materials and medical research. *NDT & E International*, Vol 26 (3).

Annex I

European Congress of Radiology

ECR is one of the world's largest international congresses and exhibitions in radiology held in early March on annual basis at the Austria Center Vienna in Vienna, Austria. ECR is attended by radiology professionals, radiographers, physicists, industry representatives, and press reporters for both the medical and consumer press. The 2018 edition of the ECR was attended by 300 exhibitors and more than 26,000 delegates[3].

[3] Information from the official ECR website, https://www.myesr.org/congress/about-ecr. Retrieved on 2018-04-04.

Interviewed Companies

Anonymous Company 1
The company is based in Eastern Europe and have been operating within radiography for 27 years.

Anonymous Company 2
The company is based in Southern Europe and have been operating within radiography for 27 years.

Anonymous Company 3
The company is based in North America and have been operating within radiography for 23 years.

Anonymous Company 4
The company is based in East Asia and have been operating within radiography for 4 years.

GMM – General Medical Merate
General Medical Merate is based in Italy and have been operating within radiography for 66 years. The company's product portfolio includes radiologic devices for fluoroscopy, radiography, mammography, mobile X-ray and C-arms. The dominant field of usage amongst the company's customers are conventional diagnostic imaging, orthopaedics, traumatology etc.

Italray
Italray is based in Italy and have been operating within radiography for 44 years.

Newtom
Newtom is based in Italy and have been operating within radiography for 22 years.

Planmed
Planmed is based in Finland and have been operating within radiography for 29 years.

Shimadzu Europa GmbH
Shimadzu Europa is based in Germany and is a subsidiary of Shimadzu based in Japan. The company have been operating within radiography for 144 years.

Ziehm Imaging
Ziehm Imaging is based in Germany and have been operating within radiography for 46 years.

AGFA Healthcare

AGFA Healthcare is based in Belgium and have been operating within radiography for 151 years.

Interview Guide

Block 1: Personal and company background

- ❏ Company position
- ❏ Time working at the company
- ❏ Involvement in the sales process and/or procurement process?
- ❏ For how long have your company been operating in the industry?
- ❏ In what sectors are your customers active?
    - Bigger customers? International, domestic?

Block 2: Purchasing criteria of the interviewee's company

- ❏ Are you using micro focus tube today, if not, what are you using instead?)
    - ❏ Why/why not? - Reasons for and against using a certain technology?
- ❏ Do you produce the tubes yourself or to you purchase them from another company?
- ❏ Time using/selling the component
- ❏ Is the product efficient and easy to use? Compatibility with other products?
    - ❏ In what way do you experience in to be efficient/inefficient
- ❏ Satisfaction with the performance of current components. Elaborate "how so?"
    - ❏ In terms of; Voltage, amperage, cathode (hot/cold), stationary vs rotating anode, Be window or not, target material.
- ❏ Most important factors technical features and specifications of the tube
    - ❏ Imaging quality, energy consumption, radiation exposure, price, product-lifetime
      (Arrange in order of importance. Ask for comments)
- ❏ Extent of customers influence in choice of components such as the tube
    - ❏ **How** do your customers influence your decisions on components?

Block 3: Characteristics of the interviewee's customers

- ❏ Customers' key criteria for product evaluation and procurement
- ❏ Customers' dominant usage area
- ❏ What do you think your customers value in your products?

Block 4: Ending questions

What do you believe will be important in the future for X-ray technology, where do you see the need for technological advancement?

CONCLUDING / CLOSING QUESTION:

What would make you replace a current product and adopt a new innovative product?
What do you believe would make you not adopt it?

Observed Barriers by Company

	Value	Complexity	Trialability	Compatibility	Co-dependence	Visibility	Communicability	Amenability	Realization	Norms & Traditions	Image	Usage	Information	Risks
Anonymous Company 1						•	•			•		•	•	•
Anonymous Company 2						•	•	•		•		•	•	•
Anonymous Company 3						•	•			•		•	•	•
Anonymous Company 4	•					•	•			•		•	•	•
GMM						•	•			•		•	•	•
Italray	•			•		•	•			•		•	•	•
Newtom						•	•			•		•	•	•
Planmed	•					•	•			•		•	•	•
Shimadzu Europa GmbH	•					•	•			•		•	•	•
Ziehm Imaging	•		•	•		•	•		•	•		•	•	•
AGFA Healthcare	•				•	•	•		•	•		•	•	•

Observed Drivers by Company

	Physical risk	Functional risk	Social risk	Economic risk	Perceived switching costs	Information overload	Existing usage patterns	Norms & Traditions	Unawareness of or Indifference to Innovation	Preference for status quo
Anonymous Company 1				•					•	•
Anonymous Company 2				•			•	•	•	•
Anonymous Company 3									•	•
Anonymous Company 4				•			•		•	•
GMM									•	•
Italray				•			•	•	•	•
Newtom	•			•					•	•
Planmed	•								•	•
Shimadzu Europa GmbH	•	•							•	•
Ziehm Imaging	•	•							•	
AGFA Healthcare					•		•		•	•