Reverse innovation in the healthcare sector

A matter of performance

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Summary

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Abstract

This research provides a performance measurement framework for Reverse Innovation (RI) within the healthcare sector. In order to design this performance measurement framework, literature analysis was combined with data from current practices that was obtained by interviewing product managers from multination companies (MNCs) in the healthcare sector that have produced RIs. Within the performance measurement framework four categories are used: financial performance, product innovation performance, sustainability performance and customer satisfaction performance. This performance measurement framework can be used to assess the performance of RIs and MNCs pursuing RIs which can help managers in their decision making and daily business management.

Introduction

Innovation is one of the most important drivers of competitive success and many different types of innovation have been identified. Recent studies focus on the fairly new concepts of frugal innovation and 'Reverse innovation' (RI). The concept of RI was first identified by Govindarajan, Trimble and Immelt in 2009. These RIs are first adopted in emerging markets as they are known for their reduction in complexity and costs (Rosca, Arnold & Bendul, 2017). Thereafter, these innovations are adopted in developed markets and therefore, RI is opposite to the traditional view of innovation in which innovations are first adopted in developed markets before transferring to developing markets such as India and China (Vernon, 1966).

In recent years, the interest in RI increased as multinational companies (MNCs) are attracted to the large and continuously growing market in emerging countries. By accessing these emerging markets with a lot of customers, these MNCs are able to maintain a sustained competitive advantage. This led to the production of different examples of RI such as the MAC 400 by GE. In addition, the research on RI increased over the past years which resulted in typology for RI, a business model for RI and the identification of barriers and facilitators for RI (Rosca et al., 2017; Tombini Wittman et al., 2021; Von Zedtwitz et al., 2015).

Furthermore, a lot of research was aimed at the healthcare sector as RI can be very successful in this sector (Harris et al., 2016). This is due to the fact that RI is an important opportunity for learning and building capacity that results in resource optimization to deliver healthcare in a cost effective and sustainable way (Snowdon et al., 2015).

However, performance measurement of RI in terms of quality, sustainability and social impact is relatively unknown. This thus means that there is a lack of knowledge concerning performance measurement of RI in the healthcare sector which resulted in the following main research question: *What metrics are needed in a performance measurement framework for RI in the healthcare sector*?

As performance measurement is a broad consept, this research focuses on financial performance, product innovation performance and sustainability performance. This is due to the fact that these three concepts are important in reflecting managerial decisions.

Research methodology

In order to find the answer to the main research question four different methods were used. First, a qualitative literature analysis was used to identify the different performance metrics that are used. Second, in order to find interviewees, examples of RI had to be identified. To do so, social media and literature was used.

Third, interviews were conducted with product managers from different MNCs in the health-care sector that have produced an RI. In total four interviews with GE, Philips, Siemens and Roche were conducted in an online environ-ment. These interviews were recorded and transcribed in order to verify these interviews. The interviews were semi-structured which allows an open discussion.

Fourth, the data was analysed by using the coding software of Atlas.ti. This was an iterative process and different clusters of codes were formed. Hereafter, the data from both literature and current practices was compared in order to identify the metrics that can be used in the performance measurement framework.

Results and discussion

Within the literature, different performance metrics were identified. Regarding financial performance, three main metrics were found: accounting-based, value-based and market-based metrics. Based on their strengths and weaknesses, the accounting-based metrics and the value-based metrics were observed to be a good combination to measure the financial performance of both an innovation and a MNC. The use of accounting-based metrics was also underpinned by the interviewees indicating that these are a common language within the MNCs.

Regarding product innovation performance, four different metrics were identified: process approach, efficacy & efficiency, innovation cap-ability and R&D metrics. Based on the strengths and the weaknesses, the process approach and the efficacy & efficiency approach are a good combination to measure product innovation performance. Furthermore, the first two processes of the process approach are similar to the first two processes of the typology of RI by Von Zedtwitz et al. (2015). The interviewees mentioned different metrics that are also in the process approach and the efficacy & efficiency model.

Regarding sustainability performance, three different type of metrics were found: indices, the sustainability balanced scorecard (SBSC) and the implications model by Shan and Khan (2016). Based on the literature, the SBSC and the implications model take into account both internal and external sustainability of the MNC. However, it was found that all four MNCs are in the Dow Jones Sustainability Index (DJSI) indicating the im-portance of the indices to measure sustain-ability performance of the company. Next, the interviewees also mentioned the use of dif-ferent metrics from the SBSC indicating that these metrics are reliable in measuring the sustainability performance.

Next, the interviewees indicated that cus-tomer satisfaction is an important aspect of performance measurement within the health-care sector. Therefore, this category was added to the performance measurement framework in which net promotor score and customer surveys are a common reference point.

Finally, the interviewees from the MNCs mentioned that they do not have different metrics to measure the performance of RI as throughout the organization, the same metrics are used. Next, the interviewees indicated that RI is more a process flow than a separate strategy and that RIs are a logical extension of products that are developed in and for emer-ging markets. Besides, the interviewees pre-sented some reasons why they are pursuing RI or transferring innovations from emerging countries to developed countries.

Conclusion, limitations and recommendations

A performance measurement framework was presented containing four different categories: financial performance, product innovation performance, sustainability performance and customer satisfaction performance.

This performance measurement framework can be used within MNCs that are producing RIs within the healthcare sector as this performance measurement framework can aid in the day-to-day decision making of managers regarding their RIs.

Furthermore, this research has shown that producing products within and for emerging markets has a couple of advantages such as a better supply chain resilience, the availability of local knowledge, a shorter development time and multiple markets within emerging countries can be reached. These advantages of producing in and for emerging markets could also be the reason that there are less examples of weak RI.

In addition, the research shows that RI is more a process flow than a separate strategy which conflicts with earlier research. This means that the MNCs observe RI as a logical extension of products that are developed in and for emerging countries which indicates that RI is a two-step process with developing in and for emerging countries as a first step before transferring it to developed countries as a second step.

However, there are a few limitations regarding the research. First, the performance measurement framework is not validated and second, only successful side of RI is observed within the interviews and the MNCs. Next, the framework is focused on the healthcare industry as certain metrics are designed for healthcare innovations. For example, cost effectiveness is an important tool within the healthcare market. As the interviewees did only mention performance metrics that are used within the healthcare industry, it may be difficult to generalize to other industries.

In order to validate the performance measurement framework, additional interviews can be done. In order to acquire more knowledge and validate this framework, it is necessary to interview employees from different department such as the R&D department and sustainability department.

Next, future research should focus on the use of this performance measurement framework to measure the performance of different types of RI. In addition, interviews can be performed within other industries in order to generalize the performance measurement framework to other industries that are known for their RIs.

Within this research, reasons for pursuing RI were presented. In future research these reasons can be validated by empirical research. Finally, future research should focus on the typology of Von Zedtwitz et al. (2015) and if this typology is used within current strategies of RI.

Preface

Dear Reader,

This thesis before you concludes my educational time at the Delft University of Technology in which I was able to develop myself in both Chemical Engineering and Management of Technology. However, I can say that graduating in two masters in times of a pandemic is challenging and different than what I had expected it to be.

When the Covid-19 pandemic struck China last year first, nobody thought it would last for more than one year and disrupt our normal lives substantially by affecting business practices, the educational system and even the way we compete in sport or exercise.

Graduating was thus a challenging and very educational task in both a personal and professional manner. Therefore, I would like to thank the people who supported me throughout this process because without them, I would not have been able to graduate in two master degrees.

First, I would like to thank Dr. Zenlin Roosenbom-Kwee who has been there for me when I had questions regarding my research. In addition, she guided me through the thesis and helped me to be focused on the 'red thread' of this research. Second, I would like to thank Prof. Cees van Beers as chair of the commission for providing me with the opportunity to graduate under his supervision. Furthermore, I am thankful for the feedback that he provided throughout the process. Third, I would like Dr. Samantha Copeland for being part of my commission but also the feedback that she provided me with and the time that she took for me to explain this feedback in the weekend. I would also like to thank all the interviewees who took time for me to help me and provide me with knowledge that supported the outcome of this thesis.

Furthermore, I am thankful for the support I have had from my family and friends. The past year has been a difficult year on a personal level with a lot of disappointments. Without their support, graduating would have been even more challenging. Finally, my special thanks to my girlfriend who was always there for me when times were tough.

Gido Drewes - 2021

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Abbreviations

BoP	Bottom of the Pyramid
BSC	Balanced scorecard
CFROI	Cash flow return on investment
CVA	Cash flow value added
DCM	Developed country's market
DJSI	Dow Jones Sustainability Index
DMNE	Developed market multinational enterprise
ECG	Electrocardiogram machine
ECM	Emerging country's market
EM	Economic margin
EMNE	Emerging market multinational enterprise
EVA	Economic value added
GE	General Electric
IRR	Internal rate of return
KPI	Key performance indicator
MNC	Multinational company
MVA	Market value added
NPI	New product innovation
NPS	Net promoter score
NPV	Net present value
OECD	Organisation for Economic Cooperation and Development
PMS	Performance management system
R&D	Research and development
RI	Reverse innovation
ROA	Return on assets
ROE	Return on equity
ROI	Return on investment
ROS	Return on sales
SBSC	Sustainability balanced scorecard
SDG	Sustainable development goal
SVA	Shareholder value added

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1 Introduction to the study

Chapter overview

This introductory chapter provides a definition of the main concept in this study. In addition, the motivation of this thesis and the research questions that have to be answered are displayed. Objectives are described and the value of this thesis is highlighted

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Section 1.1 is an introduction to reverse innovation. Section 1.2 discusses the research problem for this thesis. Section 1.3 discusses the scope of this research. Section 1.4 mentions the research objectives and questions of this research. Section 1.5 provides the scientific and managerial relevance of this thesis. Finally, section 1.6 describes the structure of this thesis.

1.1 Research Background

Innovation is one of the most important drivers of competitive success in recent years as one-third of the profit of firms in different industries is made by the sales of products developed within the past five years (Schilling, 2017). Innovations can be divided in many different types, however recent studies focuses on the fairly new concepts of frugal innovation and reverse innovation (RI) as they are of growing importance (Govindarajan & Ramamurti, 2011; Newell S., Morton J., Marabelli M., Galliers R., 2020; Rosca, Arnold, & Bendul, 2017). Both frugal innovation and RI are known for their reduction in complexity and total costs while maintaining a high value allowing the consumer in the 'Base of the Pyramid' (BoP) to use these innovations (Rosca et al., 2017). However, where frugal innovation stays at the BoP, RI transfers from developing countries such as India towards developed countries such as the United States (Govindarajan & Ramamurti, 2011)

The concept of transferring an innovation from a developing country towards a developed country is opposite to the traditional view of innovation in which innovations are first originated in a developed country and transferred to developing countries (Vernon, 1966). The development of these RIs are the results of the 'flattening' of the world which in combination with the economic liberalization resulted in the spawn of local firms that innovate for local markets. These innovations for local markets can then be transferred towards developed countries (Govindarajan & Ramamurti, 2011). Due to the fact that the customer base in developing countries is large and continuously growing, multinational companies (MNCs) from both developed and developing countries are attracted towards the local markets of developing countries. However, to attain sustainable growth by pursuing RI, MNCs need to understand emerging markets in the RI context (Malodia, Gupta, & Jaiswal, 2020).

The amount of MNCs interested in RI is growing and therefore the research in the field of RI is growing, raising a lot of questions to be answered. Govindarajan & Ramamurti (2011) set up a research agenda to get a better overview of topics to be investigated. In recent years, the gaps that were identified by Govindarajan & Ramamurti (2011) were filled as a lot of research in the field of RI was performed (Figure 1.1). This led to some major findings such as the identification of the differences with other resource-constrained innovations and the identification of different types of RI which are extensively

discussed in chapter 2 (Von Zedtwitz, Corsi, Søberg, & Frega, 2015; M. B. Zeschky, Winterhalter, & Gassmann, 2014).

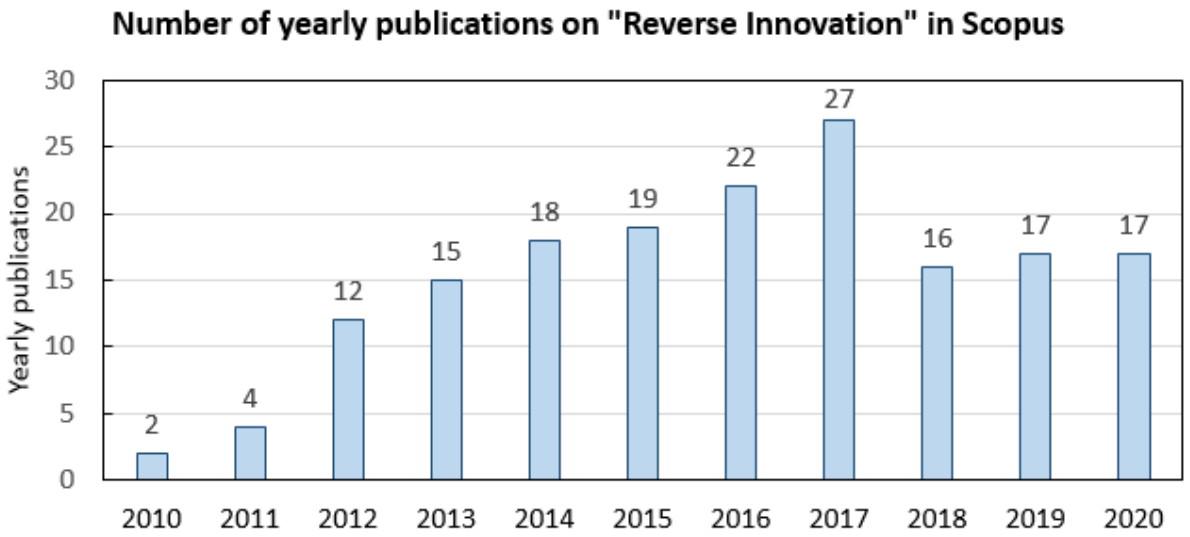


Figure 1.1 Graph of yearly publications with the keyword "Reverse innovation" in Scopus. *Note. Constructed with data obtained from Scopus on (18/01/2021)*

In addition to the increase in literature about RI, there are more and more examples of successful RI. The most well-known example of an RI is the MAC 400 produced by General Electric's (GE). In order to target the Indian market, the company produced a cheaper electrocardiogram machine (ECG) which is used for the detection of heart problems. The result was thus the MAC 400 which is a portable ECG with a weight of one and a half kilogram with only a cost of $1500. The new MAC 400 is therefore less costly and less heavy than the eight kilogram weighing machine with a price of $10,000 used in the United States (Malodia et al., 2020)

After the product introduction on the Indian market, the MAC 400 quickly became a major success leading to new opportunities for GE in India. Due to the enormous success of the product, developed countries became interested in the MAC 400 which resulted in the use of the device in ambulatory healthcare. Subsequently, GE launched a new and slightly improved version of the MAC 400 for the developed countries which is currently sold in 120 countries worldwide (Malodia et al., 2020).

This example clearly displays that RI can be very successful especially in the healthcare sector (Harris, Weisberger, Silver, Dadwal, & Macinko, 2016). This is due to the fact that RIs are an important opportunity for learning and building capacity for leading change that can influence the optimization of resources used and the findings of approaches to deliver healthcare in a cost effective, sustainable way (Snowdon, Bassi, Scarffe, & Smith, 2015). Additionally, most research on RI is aimed at the health sector as RIs are often related to frugal innovations which are known for their significant social impact by offering basic services or products in the healthcare, food, water and transportation sector (Rosca et al., 2017). However, it is important to distinguish frugal innovation and RI from each other as not every RI is in essence a frugal innovation which is further explained in chapter 2.

Additionally, the example of GE displays that BoP consumers clearly have different demands and needs compared to consumers in developed countries. Therefore, the developed market multinational enterprises (DMNEs) have to acquire different new skills in order to adapt their business models to fit the local markets' cultural, economic, institutional and geographic features (Dahan, Doh, Oetzel, & Yaziji, 2010; Govindarajan & Ramamurti, 2011; Hadengue, de Marcellis-Warin, & Warin, 2017). Thus,

emerging market multinational enterprises (EMNEs) are threatening DMNEs as the business model of EMNEs is aimed at developing innovations for developing countries and markets (Malodia et al., 2020). However, to enter the market of developed countries, these EMNEs reach out to DMNEs as the capacities of DMNEs are required (Malodia et al., 2020). Therefore, both EMNEs and DMNEs face difficulties performing RI and a more thorough understanding of the concept of RI is required.

In order to so, Govindarajan & Ramamurti (2011) came up with a general concept which defines RI as "the case where an innovation is adopted first in a poor country before being adopted in rich countries" (p. 191). Despite the fact that the main characteristic is clear, the overall definition is still conceptually vague. This is also argued by Von Zedtwitz et al. (2015) which mentions that "it is difficult to distinguish RI from other notions of innovation" and that "a reference framework is still missing" (p. 13). In addition, the definition of Govindarajan & Ramamurti is a market concept and does not take into account the location of ideation and development.

1.2 Research Problem

Von Zedtwitz et al. (2015) identified different types of RI by expanding the definition of RI. By taking into account both the place of ideation and development, Von Zedtwitz et al. (2015) described five strong types of RI and five weak types of RI. The key difference between strong and weak RI is that for an RI to be strong, two of its key innovation phases have to take place in a developing country (figure 2.2). Therefore, an innovation can be an RI when it is adopted in a developed country first if either or both the ideation and development phase takes place in a developing country (Von Zedtwitz et al., 2015). However, the typology and definition of Von Zedtwitz et al. (2015) are relatively new and therefore, there are only a few examples of weak RI (Appendix B). This research will therefore only take into account strong RI.

Furthermore, due to the fact that RI is a relatively new concept, performance measurement of RI in the area of quality, sustainability and social impact is relatively unknown (Rosca et al., 2017). In addition, the strategy of companies considering RI and their relative performance is relatively unknown which is also highlighted by Hadengue et al. (2017) as they mention that: "no one has made the effort to identify the organizational strategies linked to the practice of RI" (p. 160). This brings us to the problem statement:

Problem statement 1: There is a lack of knowledge concerning performance measurement (e.g. quality and sustainability) of RIs in the healthcare sector.

Knowledge about the performance measurement and strategy of companies performing RI can be helpful to managers in different phases of RI processes. For example, knowledge about the performance of RI can help managers to decide how to pursue RI within the organization. Furthermore, with the knowledge of performance measurement, managers are better equipped to assess the performance of their RI initiatives. In addition, knowledge about the performance of RI performed by EMNEs and DMNEs can help those companies to identify their qualities and shortcomings in order to start organising for RI. This could either be done by for example collaborations with other companies or adjusting the organisation's business strategy.

In addition, knowledge about performances of RI can help both EMNEs and DMNES ensuring effectiveness of their investments (Dewangan & Godse, 2014). Therefore, enterprises will be able to

extract more gains from their investments in RI. Finally, performance measurement helps companies to assess their current position in the market and determine their behaviour and strategic choices (Severgnini, Vieira, & Cardoza Galdamez, 2018). This results in the development of a second problem statement:

Problem statement 2: There is a lack of knowledge concerning the impact of pursuing RI in terms of the firm performance in the healthcare sector.

There exists a gap in the present literature on RI related to the performance measurement of these innovations. The knowledge about performances and performance measurement methodology could help managers decide whether to pursue RI and which type of RI suits the company's current strategy.

1.3 Scope of the research

The scope of this research is limited to the healthcare sector and therefore, only healthcare innovations are taken into account. The healthcare sector is the focus of this research due to the fact that RIs in this sector provide an important opportunity for learning and building capacity to optimize the use of resources while finding innovative approaches towards healthcare delivery in a cost-effective and sustainable way (Snowdon et al., 2015). Furthermore, the demand in the healthcare sector is outpacing the capacity of healthcare services and therefore approaches that embrace new technologies and the use of innovative processes are crucial for the sustainability of healthcare systems (Snowdon et al., 2015).

However, there are many different types of innovation such as organisational and technological innovation. In order to categorise RI, technological innovations are used in this research as it "best captures the essence of innovations from an overall perspective" (Garcia & Calantone, 2002, p. 112). A second typology is the distinction between product, process and service innovations. For this research, product innovations are used to categorise RI as these are observed to be clear outputs of an organisation (Gopalakrishnan & Damanpour, 1997). Next, RIs can be either strong or weak and as mentioned, there are only a few examples of weak RI and therefore only examples of strong RI are used in this research.

In relation to performance measurement, many different perspectives on company and innovation performance can be used (Yadav, Sushil, & Sagar, 2013). Due to the fact performance measurement is a broad concept, it is difficult to take into account all perspectives of performance measurement and therefore the following three perspectives will be taken into account for this research: financial performance, product innovation performance and sustainability performance. The reasons for taking into account these three perspectives are elaborated upon in the following paragraphs.

First, financial performance will be taken into account due to the fact that it is an important aspect for profit-driven organizations as it reflects the effectiveness of managerial decisions (Lingle & Schiemann, 1996). Furthermore, financial performance is significant in illustrating the well-being of a company (Saad & Zhengge, 2015). Next, Chiesa, Frattini, Lazzarotti, & Manzini (2009) found that companies pursuing research and development (R&D), can have three different types of objectives: diagnostic, motivational and interactive objectives. Companies pursuing diagnostic objectives are aimed at new product development and are therefore mainly using financial metrics and customer metrics (Chiesa, Frattini, Lazzarotti, & Manzini, 2009). As this research uses product innovations to categorise RIs, the

companies are aiming at new product development and therefore, financial metrics are important performance measurement metrics to take into account for this research.

Second, product innovation performance is an important factor to consider for companies pursuing RI as there is a positive link between innovation performance and overall company performance (Calantone, Vickery, & Dröge, 1995; Capon, Farley, & Hoenig, 1990). Furthermore, companies introducing product innovations had higher financial performance which is an indication of the well-being of the company (Fernandes, Ferreira, & Raposo, 2013). Finally, product innovation performance has a large impact on the competitive position of a firm as product innovation sets the determinants for product features and the production cost (Löfsten, 2014).

Third, the prioritization of sustainability is one of the drivers of innovation and therefore, sustainability performance metrics are nowadays used during product development to secure a strategic intention that is aimed at a better environmental footprint (Cobb, Schuster, Beloff, & Tanzil, 2009; Kennedy, Whiteman, & van den Ende, 2017; Provasnek, Schmid, Geissler, & Steiner, 2017). However, measuring sustainability performance is a complex process as there is an absence of general agreement on the definition of sustainability and any expectations on economic, social and environmental responsibilities are difficult to establish (Provasnek et al., 2017; Shan & Khan, 2016). Therefore, sustainability performance could be about the capability of an innovation to promote sustainability instead of measuring direct performance such as financial performance (Shan & Khan, 2016).

1.4 Research Objectives and Questions

Based on the above, this research addresses the problem that is stated in section 1.2. To summarise: there is a lack of knowledge concerning the performance measurement of RIs and the companies pursuing RI. Therefore the lack of knowledge on the behalf of performance have to addressed:

The objectives of this study are to [1] identify the different performance measurement metrics that are used in literature and current practices of RI and [2] use this data to design a performance measurement framework for RI.

Therefore this thesis is more than just an identification of performances metrics of RI. It will provide a theoretical framework in order to help managers in decision-making around RI. For example, managers can use this framework to analyse the performance of different types to find out that one type of RI might underperform compared to another type. Furthermore, managers can use this information to change their strategy in order to achieve different goals. Therefore, the propositions that can be made on the basis of this research, can be used in further research to produce a conceptual framework on the relationship between type of RI and performance.

As there is no research on performance measurement of RI, there is no theory available to develop a theoretical framework and therefore, an exploratory research methodology is best suited (Lederman & Lederman, 2015; Sekaran & Bougie, 2016). This exploratory foundation can then be used for descriptive and causal studies in order to come up with theories and hypothesis.

Main Research Question
What metrics are needed in a performance measurement framework for RI in the healthcare sector?

In order to answer the main research question, sub-questions are set up. The answers to these sub-questions will be used to partially answer the main research question and meet the research objective.

The first sub-question is aimed to provide a literature research on performance measurement in the three categories of interest. Based on this literature research, suitable metrics for the three categories of interest will be found and discussed. Therefore, this literature research helps to determine which methods are used in common research and practises and this will provide a direction to produce a measurement tool for RI. Therefore, sub-question 1 is designed to meet these objectives.

Sub-question 1:	Considering the three types of performance categories, what are the performance metrics identified in existing literature?

However, another type of data is required to design a performance measurement framework for RI. Therefore, the second question will be used to find out how performance measurement is used in current practices of RI.

Sub-question 2:	Considering the three types of performance categories, what are the performance metrics used in current practices of RI?

Based on the findings of sub-question one and two, a performance measurement framework for RI can be designed. Therefore, the third sub-question is used to compare the results of both sub-question 1 and sub-question 2.

Sub-question 3:	Based on and comparing the performance metrics gathered from the literature and those from current practice, how should an RI performance framework be developed?

By answering this final sub-question, a performance measurement framework for RI can be produced. This performance measurement framework can then be used in future studies to assess the performance of both weak and strong types of RI. Furthermore, this performance measurement framework could be an useful managerial tool for companies to assess their RI practices.

1.5 Scientific and managerial relevance

As mentioned in the introduction, this research has both scientific and managerial relevance. This research is an explanatory type of research that could result in the formation of a foundation for follow-up research in the field or performance of RIs (Lederman & Lederman, 2015; Sekaran & Bougie, 2016).

The foundation that is formed in this research can then be used for descriptive and causal research (Sekaran & Bougie, 2016). For example, this foundation can help identifying correlations between certain variables in the performance of RI. However, it is important to note that these correlations are not directly causal and therefore, causal research comes in play in which the change of one variable can be caused by another variable (Sekaran & Bougie, 2016). For example, a causal relationship can be identified between pursuing weak or strong RI resulting in higher or lower performance.

However, in relation to scientific relevance, the generalizability and validity of the research also has to be taken into account. As mentioned this research focuses on RIs in the healthcare sector. Therefore, the interviewees will provide metrics that are used within the healthcare sector and these metrics could be specific to the healthcare sector. This will make the designed performance measurement framework difficult to use in other industries and for other types of innovations. In addition, the validity of this research will depend on the amount of interviews and how well these interviewees represent the target population. Therefore, the interviewees need to have experience with RI within the healthcare sector.

In addition to the scientific relevance, this study can be an important foundation for companies pursuing RI. As innovations are the main drivers of competitive success, knowledge about innovations and their performance could be useful in terms of decision making (Schilling, 2017). Additionally, RI is a relatively new concept in which knowledge is still lacking and as MNCs are more and more participating in RI, more knowledge is required on innovation performance. Therefore, the performance measurement framework that is designed within this study, can be used to identify innovation performance.

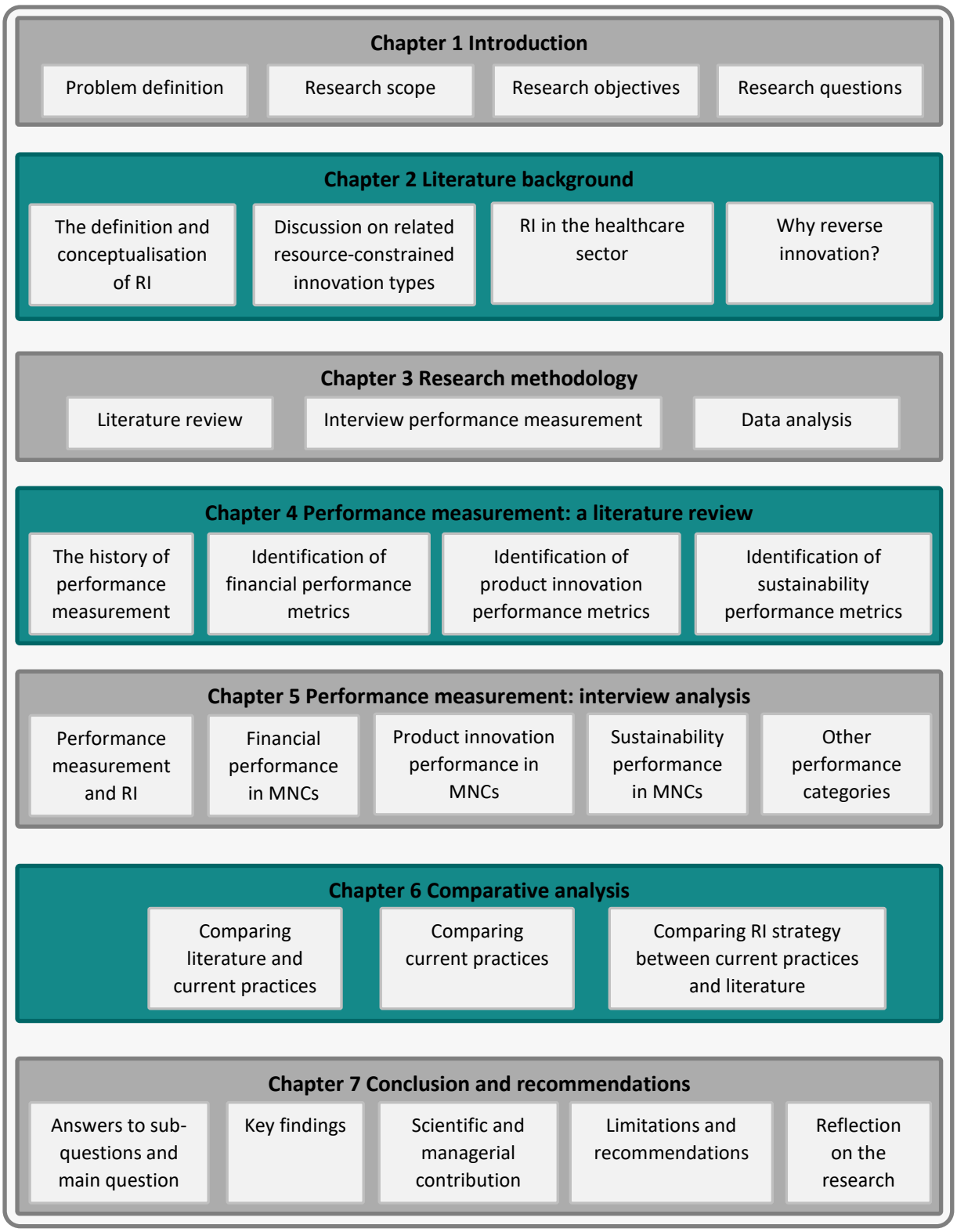
1.6 Thesis structure

In order to answer the research questions and achieve the objectives, the thesis follows the following structure. In Chapter 1, the research objectives and the questions to be answered, are defined. In the next chapter, Chapter 2, a background on RI is provided and the relevant literature on R is discussed. Furthermore, a categorisation for RI is identified and the operational definition of RI that is used in this thesis, is provided. Chapter 3 discusses the methods that are used to answer the research questions.

Hereafter, Chapter 4 starts with the qualitative literature review on performance measurement to identify different types of performance metrics and their strengths and weaknesses. Based on these strengths and weaknesses, different metrics are proposed to be more suitable for assessing the performance of RIs. However, in order to produce a performance measurement framework for RI, additional knowledge is required.

This additional knowledge on performance measurement is presented in Chapter 5. In chapter 5, the analysis of the interview data is provided. Chapter 6 takes into account both the knowledge from literature and the interviews to form a performance measurement framework.

In chapter 7, a conclusion is presented based on the comparative analysis in chapter 6. Furthermore, chapter 7 discusses the limitations of the study and some recommendations for future studies. Hereafter, the appendix will provide additional information on innovation, RI examples and interview data and the performance measurement framework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2 Literature background

Chapter overview

This chapter provides a review of the literature and main findings on RI. This chapter therefore aims to provide a background on RI and how the concept of RI relates to other types of innovation.

Section 2.1 discusses the development of RI as a concept. Section 2.2 describes the relation between RI and other types of innovation such as frugal innovation. Section 2.3 discusses the categorisation of RI that will be used in this research. Section 2.4 provides an overview of the research about RI in relation to the health sector. Finally, section 2.5 provides a description of the relevancy of RI to scholars and practitioners.

2.1 Reverse innovation as a concept

Literature on RI has increased the past years as the potential of RI for both EMNEs and DMNEs is increasing. As a result, various definitions for the concept of RI were proposed by different researches. Govindarajan & Ramamurti (2011) defined RI as "the case where an innovation is adopted first in a poor country before being adopted in rich countries" (p. 191). However, different researchers questioned this definition and therefore broadened the definition or changed the conceptual framework (Hadengue et al., 2017; Malodia et al., 2020; Von Zedtwitz et al., 2015)

2.1.1 Development of RI as a concept

The concept of RI was first introduced in early 2000s when Pralahad introduced trickle-up innovation in 2004 (Hadengue et al., 2017). This type of innovation refers to any innovation that trickles-up from the BoP to the developed countries. However, it differs from the current concept of RI as trickle-up innovation is meant to serve the BoP initially where an RI could be luxury product sold in an emerging market first before transferring to the developed market indicating that RI is driven by constraints specific to emerging markets rather than cost constraints (Hadengue et al., 2017).

Hereafter, a similar concept was proposed by Brown & Hagel in 2005 by the development of blowback innovation. This research underlined the importance of adapting products to emerging markets needs by DMNEs in order to avoid displacement by EMNEs (J. S. Brown & Hagel, 2005). This idea is covered in the concept of RI and some researchers argue "that this new innovation strategy was a prerequisite if DMNEs wanted to survive the rise of emerging markets and their local firms" (Hadengue et al., 2017, p.144).

Despite the fact that the concepts of trickle-up innovation and blowback innovation are quite similar to RI, these concept did not gain a foothold in research. It was not until 2009 before Govindarajan & Trimble first introduced RI. But why did this concept gain a foothold? This was due to the fact that the concept of RI did not necessarily consist of "innovations to very low-income consumers or innovations of lower qualities but rather innovations arising from new contexts" (Hadengue et al., 2017, p.144).

In 2009, Immelt, Govindarajan & Trimble were the first researchers to mention RI. In their paper, RI was defined as the opposite of the traditional glocalization approach which means that companies develop products at their home country and then adapt the products to local conditions in order to distribute them worldwide (Immelt, Govindarajan, & Trimble, 2009). The glocalization approach was an useful approach in the situation were rich countries took account for the majority of the market and other developing countries did not offer a lot of opportunities. However, as mentioned in the introduction this situation is changing due to the flattening of the world and economic liberalization (Govindarajan & Ramamurti, 2011; Immelt et al., 2009)

Immelt, Govindarajan & Trimble were thus the first to mention RI and even described the process of RI as a possible disruption towards the glocalization approach. However, a clear definition of RI was still missing. Therefore, Govindarajan & Ramamurti (2011) developed a definition of RI based on the product life cycle theory by Vernon (1966) and the diffusion of innovation model by Rogers (1962). These theories focus on the market of adoption instead of the place of development and therefore, RI was observed to be a market process (Govindarajan & Ramamurti, 2011).

2.1.2 A market process

According to Govindarajan & Ramamurti, RI can thus be explained by looking at the market of adoption. This means that an innovation is an RI if it transfers from an emerging country's market (ECM) to a developed country's market (DCM). Despite the fact that this is a general definition, the transfer from an ECM to a DCM requires three stages. The first stage is the diffusion and adoption of an innovation in an ECM. Hereafter in the second stage, the innovation transfers to another ECM before transferring to a DCM (Govindarajan & Ramamurti, 2011). The first step is therefore not surprising as both ECM's may have customers with the same characteristics. However, transferring an innovation from an ECM to a DCM is against the traditional approach of innovation.

Therefore, Govindarajan & Ramamurti (2011) came up with five possible reason for an innovation to trickle-up from an ECM to a DCM. The first mechanism is that innovations developed for ECM, might have a market or an appeal for poor people in DCMs. This mechanism indicates that for example "low-cost housing, medical care or banking may appeal to the inner city or rural poor in developed countries" (Govindarajan & Ramamurti, 2011, p.196). Despite the fact that this part of the market may be small, it could be a good start for a growth in developed countries. Second, the price reductions in ECMs can help expand the demand in DCMs due to the price elasticity effect.

Third, innovations for ECMs may incorporate new features that can create new market segments in the DCMs. Examples of these features are the ease of use and the portability that are used in the MAC 400 device by GE. Fourth, technologies and products aimed at ECMs can be improved due to advances in technology which could lead to the satisfaction of the needs in DCMs. Finally, ECMs are expected to leapfrog to latest technologies as ECMs due to the fact that these markets are unencumbered by complex regulatory systems and sunk investments in old technologies (Govindarajan & Ramamurti, 2011).

In addition to the reasons for an innovation to transfer from an ECM to a DCM, the role of different types of adopters can be crucial. In most cases, lead users are crucial for the adoption of innovations as they are the first to adopt a new product, process or service. Based on the experiences of these lead users with the product, process or service, companies can improve their innovation making lead users useful in the development of an innovation (von Hippel, 1986). For RI, Govindarajan & Ramamurti

(2011) assumed that 'laggards' are more important for the development as laggards have the characteristic to be happy with 'good enough' quality. These characteristics can be observed to be equal to the characteristics of consumers in ECMs and therefore, companies can use RI to turn these laggards into mainstream users (Govindarajan & Ramamurti, 2011).

2.1.3 Expanding the definition of a market process

As mentioned in the introduction of this thesis the main characteristic of RI is clear, however, the general concept is still vague (Malodia et al., 2020; Von Zedtwitz et al., 2015). Therefore, different researchers expanded or reformed the definition of RI. First, different researchers defined the concept of RI as a combination of a product innovation and a market process which resulted in the definition of an RI as designed for ECMs instead of adopted in ECMs (Judge, Hölttä-Otto, & Winter V, 2015; Snowdon et al., 2015).

This thus changes the concept of RI but it is still difficult to distinguish RI from other types of resource-constrained innovations such as 'Cost innovation', 'Gandhian innovation', 'Jugaad Innovation' and 'Frugal innovation' (Von Zedtwitz et al., 2015; M. B. Zeschky et al., 2014; M. Zeschky, Widenmayer, & Gassmann, 2014). These types of innovation are also designed for ECMs as they are known for their great value and low costs. Zeschky et al. (2014) even identified that RI is just a form of either, cost innovation, good-enough innovation or frugal innovation that transfers to a DCM. This indicates that RI has the same characteristics as one of the three innovation types mentioned above which are mentioned in table 2-1. The only difference between RI and cost, good-enough and frugal innovation is that RI transfer to a DCM.

Table 2-1 Characteristics of cost, good-enough and frugal innovation (M. B. Zeschky et al., 2014; M. Zeschky et al., 2014)

	Cost innovation	**Good-enough innovation**	**Frugal innovation**
Characteristic	Product with same functionality but lower cost	Product with different functionality but lower cost	Product with new functionality with lower cost

However, according to Von Zedtwitz et al. (2015) this definition and new perspective does not take into account the place of ideation or development. Therefore, the definitions based on the market introduction discard any other reversal flows during the development of an innovation. In order to come up with a broader definition of RI, Von Zedtwitz et al. (2015) recognize innovations to be a process consisting of four stages which are concept ideation, product development, primary target market and second market introduction (Godin, 2006; Von Zedtwitz et al., 2015)

This linear innovation model thus allows different reversal flows in between the different phases or stages. For example, ideation can take place in a developing country and afterwards, development can take place in a developed country indicating a reversal flow of innovation. This broadens the initial market process and product innovation typology by adding ideation-based and development-based RI (Von Zedtwitz et al., 2015). By broadening the definition of RI as an innovation process, ten types of RI were identified (Figure 2.2).

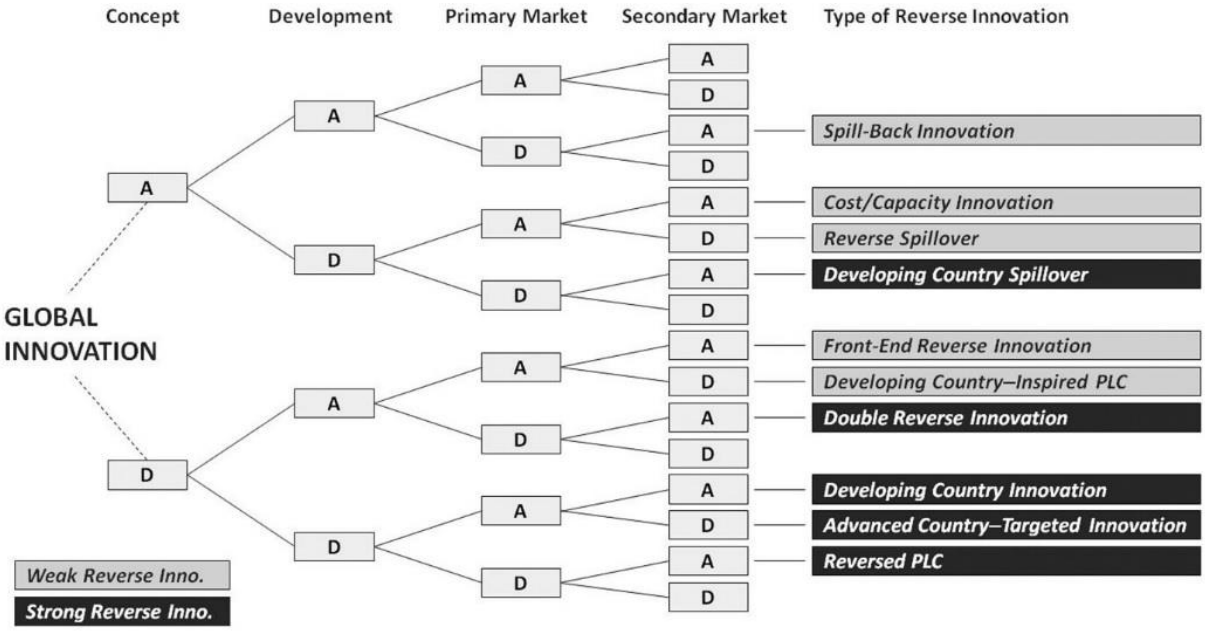

Figure 2.1 The different phases of the innovation process and the reversal flow of innovation. In this figure, A represents an advanced country and D represents a developing country. From *A Typology of Reverse Innovation* by Von Zedtwitz et al. (2015, p.18).

In addition, Von Zedtwitz et al. (2015) divided these ten types of RI in strong and weak types of RI. In order for an RI to be a strong RI, two of the four phases of the innovation process have to take place in a developing country and ultimately, the product has to be introduced in the DCM (Von Zedtwitz et al., 2015). The definition of ideation-based and development-based are in contrast with the initial market definition of Govindarajan and Ramamurti as market introduction can occur in a DCM before transferred to an ECM if ideation or development occurs in the developing country (Von Zedtwitz et al., 2015).

As Von Zedtwitz et al. (2015) were able to identify more types of RI, a clear definition and consensus about the definition of RI is still missing according to Hadengue et al. (2017). In order to solve this problem, they described that RI is essentially driven by the constraints in the ECMs. Therefore, RI is a consequence of the constrained environment in these ECMs rather than the consequence of the ECM itself. This means that RI is more a concept of new and constrained markets rather than a concept of ECMs (Hadengue et al., 2017). However, Hadengue et al. (2017) did not come up with a clear definition of RI and stated that the clarification of the definition of RI is a challenge for future research.

Therefore, Malodia et al. (2020) conceptualized RI as a multidimensional construct and defined RI as "Clean slate, super value products that are technologically advanced created to meet the unique needs of relevant segments, initially adopted in the developing countries followed by the developed countries" (p. 1014). This definition however discards the analysis of Von Zedtwitz et al. (2015) that RI can also be adopted in a developed country first if either the ideation phase or the development phase takes place in the developing country. Therefore, the definition of Von Zedtwitz et al. (2015) allows the differentiation between RI and other concepts aimed at the developing countries such as frugal innovation, cost-innovation and good-enough innovation. The differences between these three types of innovation and RI will be further explained in section 2.3

2.1.4 Reverse innovation as a strategy

Some researchers argue that the development of an RI depends heavily on the strategy of a MNC indicating that RI is more than a concept but also a strategy (Kumar & Srivastava, 2020; Rosca et al., 2017). First, Govindarajan & Trimble (2012) mentioned that the global localization strategy of modifying products generated for developed countries to suit developing countries is restricting multinational companies nowadays. Therefore, they recognised that in order to take advantage of RI, companies need to change their strategy (Govindarajan & Trimble, 2012). In addition, Govindarajan & Trimble (2012) identified five gaps between developing countries and developed countries in order to help multinational companies what type of change is required in order to produce RI. However, a clear cut strategy that is used by multinational companies or local companies in developing countries is not mentioned.

As mentioned, the gaps identified in the article by Govindarajan & Trimble (2012) are more a guideline in order to help companies identify the differences between both markets. Bhattcharyya et al. (2017) provided a different approach by identifying criteria to assess potential RIs. It starts with the identification of four criteria of an innovation to be successful in a developing country which are accessibility, cost effectiveness, scalability and effectiveness (Bhattacharyya et al., 2017). In order to become an RI, there are four new criteria which are the compatibility, the novelty, the receptivity and the potential gap in the developed country's market (Bhattacharyya et al., 2017). Despite displaying the characteristics of successful RIs, the article of Bhattacharyya et al. (2017) does not mention any strategies and is therefore only to be considered helpful for managers to determine whether innovations might become RIs.

This strategy perspective on RI is encountered in the article of Rosca et al. (2017) in which a business model is produced for frugal innovation and to some extent RI. However, the business model of companies producing frugal and RIs is mainly focused on cost cutting and low business margins. In addition, it is important to include local companies in the value chain and marketing should be changed to attract local customers (Rosca et al., 2017). Moreover, cooperation between actors from emerged countries and emerging countries is helpful (Kumar & Srivastava, 2020; Rosca et al., 2017). As mentioned, in cases of RI, costs are still the main driver but it is important to note that the RI products show characteristics of a differentiation strategy as well (Rosca et al., 2017).

Kumar & Srivastava et al. (2020) emphasized that a marketing mix strategy is required for companies acting in both developing countries and developed countries. Additionally, the concept of open innovation must be considered based on the different markets as open innovation may be less viable in developing countries (Kumar & Srivastava, 2020). Next to the open innovation strategy, it considers that an RI strategy aims to market to underserved customer segments in both the developing and developed countries (Kumar & Srivastava, 2020). This view of RI as a separate strategy complies with the definition of Von Zedtwitz et al. (2015) rather than viewing RI as a frugal innovation that trickles up to a developed country.

2.1.5 Operational definition of reverse innovation

Different definitions for RI are proposed in the past years by different researchers and based on different concepts. However, there is no consensus for the definition of RI as it is still a new concept. In this section, an operational definition for RI is stated that will be used throughout this thesis. In the literature, the concept by Govindarajan & Ramamurti (2011) on the transfer of an innovation from an

ECM to a DCM is the most used (Hadengue et al., 2017). However, Von Zedtwitz et al. (2015) expanded their view and identified additional types of innovation which cannot be discarded. Furthermore, the different types of strong RI are of main interest in this research as their performance will be investigated.

Based on the available research and the problem statement of this research, the following definition will be used:

Operational definition: Reverse innovation is "any type of global innovation that, at some stage during the innovation process, is characterized by a reversal flow of innovation from a developing country to an advanced country, and that is eventually introduced to an advanced country's market" (Von Zedtwitz et al., 2015, p. 17)

2.2 Reverse innovation and other types of innovation

In the previous section, it was already described that different papers suggest that RI is closely related to other types of innovation such as 'cost innovation', 'Gandhian innovation', 'Jugaad Innovation' and 'Frugal innovation' (M. Zeschky et al., 2014). Furthermore, they stated that RI is a form of cost innovation, frugal innovation or good-enough innovation (M. Zeschky et al., 2014). In this section, the related concepts to RI will be explained and the relation between both the related concepts and RI will be discussed.

2.2.1 Frugal innovation

Frugal innovation and RI are closely related as they are known for satisfying customer needs in emerging markets (Rao, 2013; Rosca et al., 2017). In order to further discuss the relationship between frugal innovation and RI, a clear definition of frugal innovation is required. Rao et al. (2013) described frugal innovation as an innovation that satisfies the bottom of the pyramid having the following characteristics "cheap, tough, easy to use and developed with minimum amount of raw materials" (p. 65). These characteristics indicate that frugal innovation is an art of doing "more with less". This definition can be expanded by arguing that frugal innovations are known for their significant social benefit by offering for example food and health services at very low prices (Rosca et al., 2017). In addition, the combination of low-cost, quality and simplicity makes frugal innovations a significant disruptive force (Rao, 2013).

Next, the relation between frugal innovation and RI can be determined. Some argue that RI is a form of frugal innovation that is just transferred to developed countries. For example, Zeschky, Winterhalter & Gassmann (2014) argues that RI is built on frugal innovation as innovations that were designed as frugal innovations transferred to developed market to become an RI. This is also underlined by Zeschky, Widenmayer & Gassmann (2014) as they mention that "reverse product innovations are essentially frugal product innovations which are taken to the markets of developed, Western countries" (p. 270). They also propose that RI is built on frugal innovation but more on a market perspective than a technological perspective. In addition, RI requires a 'frugal mindset' in the R&D department in order to effectively develop these RIs (M. Zeschky et al., 2014).

However, considering the definition of RI proposed by Von Zedtwitz et al. (2015), frugal innovation is not observed as a building block of RI as RI does not have to be adopted first in emerged markets. By expanding the definition with the ideation-based and development-based elements, RI is not just a frugal innovation transferred to a developed market. Therefore, frugal innovation and RI could be considered two different concepts which are not just built on each other. This is also underpinned by Rosca et al. (2017) as "reverse innovations do not necessarily target poor people in industrialized countries, but can also target the middle class with luxury goods (wine refrigerator) or young people trying to be stylish (bamboo bike)" (p. 142). Next, Agarwal & Brem (2012) and Brem & Wolfram (2014) also mention that frugal is specifically aimed at low-income markets while RI is selling products in developed markets after being developed or sold in emerging markets first.

Despite the fact that frugal innovation and RI are two different concepts, there are examples where a frugal innovation becomes an RI. Therefore, some notions that hold for frugal innovation can be considered to be useful for RI. For example, different strategies used for frugal innovation can be useful for developing RI. In addition, multinational companies aiming at emerging markets should focus on both frugal innovation and RI (Agarwal & Brem, 2012). Firms should thus be able to build both frugal and RI capabilities and managers might need to develop a frugal mind-set in order to develop RI (Zeschky, Widenmayer, & Gassmann, 2014).

To summarise, frugal innovation and RI share some characteristics and some researchers argue that RI is built on frugal innovation. However, considering the definition of Von Zedtwitz et al. (2015), there are types and examples of RI that are not in essence a frugal innovation and furthermore, RIs do not necessarily target poor segments of developing countries in contrast to frugal innovation. Thus, frugal innovation and RI will be considered to be different categories in this research.

2.2.2 Cost innovation

Cost innovation is quite similar to frugal innovation but as mentioned in section 2.2.3, cost innovation is only aimed at lower cost. This means that both the market and the product itself cannot be classified a new as their level of novelty is low (M. B. Zeschky et al., 2014). The strategy of cost innovation is mainly based on cutting costs as much as possible to turn an expensive good into a commodity (M. B. Zeschky et al., 2014). Therefore, cost innovations are characterised to be process innovations as process innovations can help in the reduction of costs. For example, the Chinese company BYD decreased the cost of lithium-ion batteries by 70 percent by developing a new method to produce these batteries (M. B. Zeschky et al., 2014).

Cost innovation is thus known for its focus on cost cutting and therefore it has the potential to change the existing rules of global competition. Cost innovation has three faces (Williamson, 2010). First, challengers in global competition start offering high technology at low cost to the customers. By developing high technology at low cost, the wisdom that high technology is restricted to high-and products is interrupted. Second, the new competitors from developing countries present variety at low cost to the customers which again challenges the wisdom that variety and customisation is costly. Third, competitors from developing countries are moving niche products into the mass market which disrupt the conventional wisdom of focus strategies (Williamson, 2010).

By trickling up to a DCM, a cost innovation can become an RI which can help firms broaden their product portfolio to draw attention from cost-conscious or efficiency-seeking customers in developed markets. However, as with frugal innovation, cost innovation is not always a building block of RI. There

are examples of cost innovation that transfer to developed markets but not all cost innovations have the potential to trickle up to a DCM due to the fact that cost-innovations are aimed at social problems in emerging markets that may not be applicable in developed markets (Rosca et al., 2017). Furthermore, cost innovation and RI have a different level emerging market orientation which means that there is a different focus on researching the current trends in the emerging market (Brem & Wolfram, 2014).

In sum, there are examples of cost-innovations that become RIs. Therefore, some concepts and theories for cost innovations can be useful to take into account when performing RI (M. B. Zeschky et al., 2014). However, cost innovation is not always the building block of an RI and RI is observed to be a stand-alone strategy or concept (Brem & Wolfram, 2014; Rosca et al., 2017).

2.2.3 Good-enough innovation

Good-enough innovations are also designed for low costs but as a difference good-enough innovations also consist of products with new functionalities to meet resources constraints. Therefore, good-enough innovations are re-engineered to solve problems in developing countries and fit the use requirements of these markets (M. B. Zeschky et al., 2014). For example, a Swiss company Mettler Toledo developed a good-enough weighing scale for the Chinese market that had both a reduction in cost and more basic minimum features than the products sold in the Western market (M. Zeschky, Widenmayer, & Gassmann, 2011).

In order to come up with good-enough innovations, the value-adding functions have to identified while eliminating functions that do not deliver value for the customers. Therefore, good-enough innovation require some degree of product novelty which arises from a focus on “core features, increased robustness, high ease of use and manual rather than automated processing” (M. B. Zeschky, Winterhalter, et al., 2014, p.27). As with cost innovation, pursuing good-enough innovation and trickling it up towards the DCMs can help firms in extending their portfolio at the low end (M. B. Zeschky et al., 2014).

Therefore, firms can improve their business strategies by pursuing good-enough innovation but RI is not just built on good-enough innovation as ideation-based and development-based are different aspects of RI that are not captured in the definition of good-enough innovation. Despite the fact that RI and good-enough innovation are thus different concepts, there are some examples of good-enough innovations that trickle up to DCMs. Therefore, some strategies that companies use for good-enough innovation can be used for RI.

2.3 Categorisation of RI

In sum, innovations can be categorised in a lot of different types such as incremental and radical innovations but also product, process and service innovations. In this thesis, product innovations are used to categorise RIs as these type of innovations can be observed to be clear outputs of organisations. In addition to RI, the previous section displayed that there are more types of product innovation that are aimed at developing countries such as frugal innovation, cost-innovation and good-enough innovation.

Despite the fact that some RIs are built on one of these three types of innovation, RI is categorised as a stand-alone type of innovation as not all RIs are built one of these three types of innovation aimed at developing countries. This is due to the fact that the definition of Von Zedtwitz et al. (2015) led to the development of new types of RI such as ideation-based and development-based RIs that are not brought to developing markets. Furthermore, some examples of RI are luxury products which cannot be identified to be a frugal innovation, a cost innovation of a good-enough innovation. Figure 2.3 shows the categorisation of innovation that is used to identify RI and its different types of RI that were established by Von Zedtwitz et al. (2015). The blue blocks indicate the types of innovation which are of focus for this research.

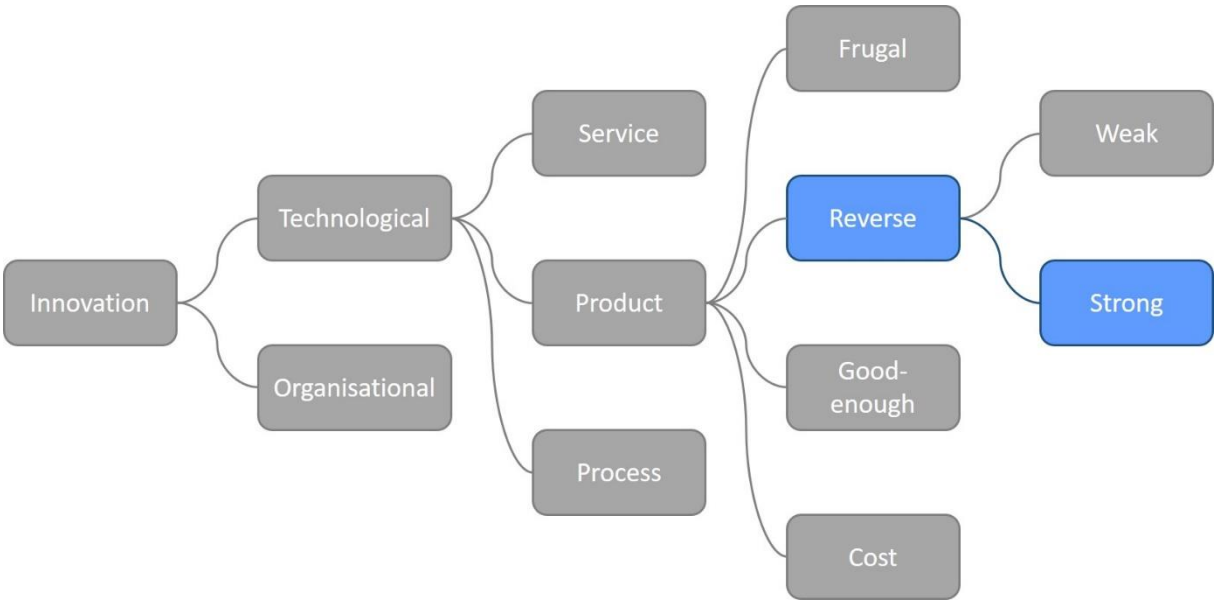

Figure 2.2 Categorisation of RI

2.4 Reverse innovation and the healthcare sector

As mentioned in the introduction, the scope of this thesis is aimed at the healthcare sector due to the fact that RI is gaining traction in this sector in order to generate innovative ideas (DePasse & Lee, 2013). Furthermore, the market in this segment is a growing opportunity for MNCs. Therefore, a lot of research was aimed at this sector.

2.4.1 Diffusion and spread of RI

First, DePasse & Lee (2013) discussed the diffusion and spread of RI in the healthcare sector by using the diffusion model of Rogers (2003) as a basis. The dynamics of innovation spread of Rogers suggest that there are five groups of adopters with their own characteristics (E. M. Rogers, 2003). First, innovators are known to firstly adopt an innovation. Second, the early adopters are likely to adopt the innovation and they are known for the high degree of opinion leadership. Third, the early majority adopt the innovation hereafter followed by the late majority and the laggards (E. M. Rogers, 2003). Based on this dynamic spread model of Rogers, DePasse & Lee (2013) proposed a model that describes how an innovation will trickle up from the early adopters of a developing country towards the innovators of a developed country (Figure 2.4).

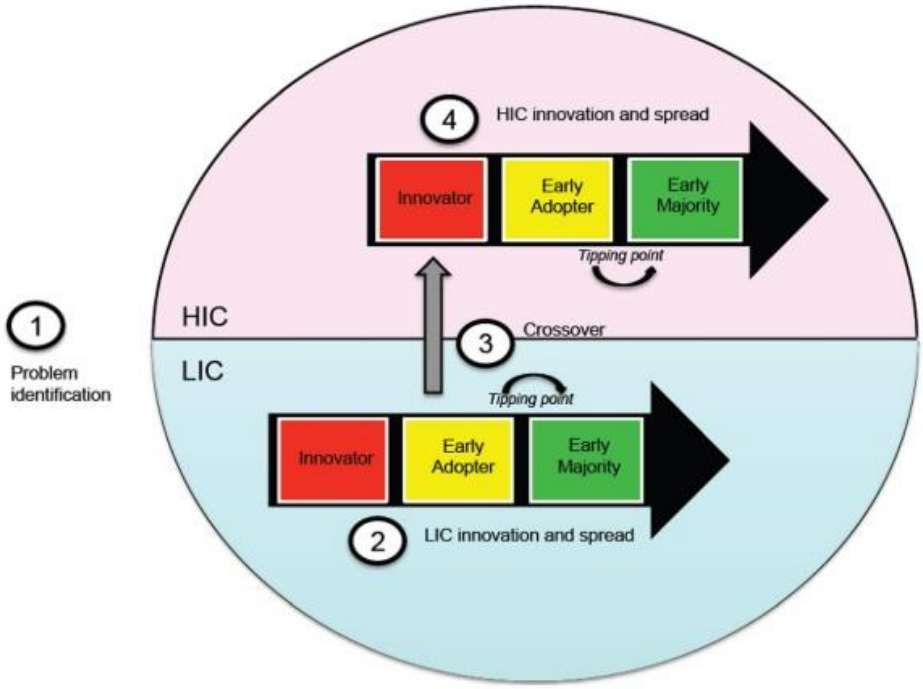

Figure 2.3 A model for the diffusion of RI in the healthcare sector. From *A model for 'reverse innovation' in health care* by DePasse & Lee (2013, p.3)

Next, Harris et al. (2016) broadened the vision of the DePasse & Lee, by looking at RI from a knowledge perspective. They found that the driver of the learning process in RI is completely one-sided from the developed country. This means that developing countries do not necessarily sell or export ideas to developed countries (Harris et al., 2016). In addition, RI cannot be described as either a linear process or as a passive diffusion process. However, diffusion and adoption is observed to be difficult as the association with frugality leads to the view that the innovation is just a low-quality alternative to existing products (Harris et al., 2016).

Finally, Hossain et al. (2016) took another perspective on the diffusion of frugal innovations and RIs mentioning four different patterns of diffusion which are local diffusion, proximity diffusion, distance diffusion and global diffusion which can be related to as RI. In addition, Hossain et al. (2016) mentioned that it is unlikely that a local diffusion directly can become a global diffusion or RI indicating that a base level of proximity diffusion is required. However, the diffusion routes and innovations mentioned in this paper are mainly market based and do not take into account the other types of RI.

2.4.2 Barriers and facilitators

Diffusion and adoption of innovations depends on the type of adopters and the strategies to interest these adopters as well as the barriers faced and facilitators encountered during the innovation process (Rowthorn, Plum, & Zervos, 2016). For example, companies may face three different types of legal and regulatory barriers during the innovation process (Rowthorn et al., 2016).

First, in the case of purely legal barriers, innovators referred to tort liability in the case of healthcare products that deviate from the standard (Rowthorn et al., 2016). Second, regulatory barriers come into play in the form of task shifting, international physician licensure and reimbursement. Third, some firms face perceived legal and regulatory barriers which might result in the fact that a company might

not even attempt to bring a service or product to the market (Rowthorn et al., 2016). However, the study of Rowthorn et al. (2016) applies to the United States and is therefore difficult to generalize for other countries due to the fact that these other countries can have different legal rules.

Recently, Tombini Wittmann et al. (2018) wrote an integrative literature review in order to come up with more barriers and facilitators. It was found that the one of the main barriers for a company to invest in RI is to go against the dominant logic of the concept that innovation goes from a developed country to a developing country. In addition, companies are resistant to the transfer of power and companies have fear of products cannibalization (Tombini Wittmann et al., 2018; Zhu, Zou, & Xu, 2017). Furthermore, the perceived degree of product adaption that is needed for RI forms a barrier to innovate (Zhu et al., 2017). Besides, companies might have difficulties in managing the diversity of people in order to participate successfully in RI.

Table 2-2 Barriers and facilitators for RI in alphabetic order. From *Barriers and facilitators of Reverse Innovation: An Integrative Review* by Tombini Wittman et al. (2018, p.11)

Barriers	**Facilitators**
The dominant logic and institutionalized thinking of multinationals	Decentralization increase of R&D areas
The fear of products cannibalization	Economic liberalization in emerging markets
The institutional distance between developed countries and emerging markets	Growing demand from emerging markets for new products
The legal and regulatory barriers	International partnerships movement in the health area, aiming the mutual responsibility and definition of a joint agenda
The need of the multinational corporations to expand their markets and not to lose space for low-cost solutions	Low-cost workforce offer, government support, entrepreneurial spirit and sped and creativity of the Chinese internet industry
The perception that reverse innovation develops low technology products and limited resources	Open innovation
The preconception of the professionals of the matrix concerning the peers of the subsidiaries of developing countries	Openness to participate in collaboration networks
The resistance to transfer power and control away from the matrix	Possibility for multinationals to strengthen their competitive advantage and economic growth
The scepticism of health professionals in high-income environments	Search for simpler/cheaper products and the fast pace of large-scale Chinese government projects
To change-resistant culture	Support of infrastructure, professionals and local policymakers in developing countries
To manage the diversity of people and cultures in the R&D process	The advancement of the use of technology to economic and easy-to-use innovations
	The co-location of foreign and domestic firms
	The diversity in the early stages of product development to reduce uncertainties
	The multinational's need to expand their markets and profits to survive in the global market

In contrast, there are also a lot of facilitators for RI supporting the growth of interest in RI. One of the main facilitators is the growing market from developing countries. Subsequently, open innovation and collaboration in networks provides a lot of opportunities for RI as knowledge transfer becomes more accessible. This is also observed by co-localization and decentralization of firms. Most importantly, the support of infrastructure and local policymakers in developing countries is increasing (Tombini Wittmann et al., 2018). In contrast to the research by Rowthorn et al. (2016), Tombini Wittmann et al. (2018) provided more facilitators and barriers of RI which are presented in table 2-2.

2.5 Why Reverse innovation?

As mentioned in the introduction, RI is a growing concept in the literature as ECMS are continuously growing which raised the interest of MNCs. Furthermore, flattening of the world and economic liberalization increased the amounts of RIs. Next to the value that RIs bring to MNCs, RIs are also known for their link with sustainable development (Rosca et al., 2017). This section will describe the relevancy of studying RI from a financial perspective and from a sustainability perspective indicating the social relevancy of RIs.

2.5.1 Economic value

The economic value plays an important role in the motivation for companies to participate in RI. The large customer base in ECMs are thus seeking sustainable growth and new market opportunities (Malodia et al., 2020). ECMs and its customer base offer great opportunities for the production of profit by MNCs. Furthermore, new markets can be created providing new economic value: “For example, new markets for agricultural waste were created, where farmers can make extra money by selling it” (Rosca et al., 2017, p. S142).

2.5.2 Product innovation value

In order to achieve this economic value, product innovation can play an important role as companies that produce new product innovations have higher financial performance (Fernandes et al., 2013). Furthermore, pursuing product innovation is crucial for companies that act in emerging markets as there are visible weaknesses in the infrastructure, technologies and the market stability (Atiase & Dzansi, 2020). This means that product innovation is not only observed to be a source of profitability but also a source of productivity and growth (Atiase & Dzansi, 2020; Li, Wang, Li, & Zhao, 2007). Finally, product innovation is observed to be critical for corporate renewal, survival and strategic foresight (Atiase & Dzansi, 2020)

2.5.3 Sustainability value

Sustainability refers to the need of “creating resilient systems regarding ecology, economy as well as society while respecting the ecological capacity and viability” (Rosca et al., 2017, p. S133). Therefore, sustainable innovations are innovations that provide some progress concerning social economic and ecological concerns. This means that by having an indirect ecological impact, innovations have to realize improvements on an ecological level by reducing energy, land, resource intensity, emissions and waste. Indirect social impact concerns the quality of human life and the quality of healthcare. A sustainable innovation should thus combine economic value with environmental and social benefits (Rosca et al., 2017).

Environmental impact

In developing countries, there are increasing environmental issues and therefore sustainability management and development is gaining ground in those areas. As RIs are often resource-constrained innovations aimed at those areas where environmental issues are growing, RIs can offer positive indirect environmental impacts (Brem & Ivens, 2013). There are some examples that show that there is a reduction of used material and resources which reduce emissions. Some examples even show the use of waste and renewable materials in order to reduce resource consumption (Rosca et al., 2017).

Social impact

Based on the typology by Von Zedtwitz et al. (2015), RIs will always target ECMs, either as their first market or as the secondary market. This indicates that by producing RIs, people in developing countries can be reached. However, where frugal innovations are always aimed at the BoP, RIs can be targeted at the luxury segments of ECMs (Hadengue et al., 2017; Rosca et al., 2017). Therefore, the indirect social impact of RIs depends on the market segment where the innovation is aimed at. Brem & Wolfram (2014) mention therefore that the indirect sustainability impact of RIs might be on a low level compared to other types of innovation such as frugal innovation.

RIs that are aimed at the BoP of the ECMs, will improve the quality of life as these innovations are known for their low cost. These low costs make the products more accessible to poor people but it will also create leftover money that people can spend on education, food and other goods or services. This is also considered for health services such as hospitals that can buy cheaper medical devices allowing poor people to use these health services (Rosca et al., 2017). As mentioned, by producing cheaper products, the access to education increases which will result in a greater access to information. Finally, the creation of jobs increases through RI as development, productions and distribution is required which is important for general life status that can serve as a trigger for more entrepreneurial business ideas (Rosca et al., 2017).

Socio-economic impact

A part of the economic value that RI can provide is already mentioned in the previous section. For example, by increasing the amount of jobs, economic welfare in a developing country will increase. Additionally, RI and frugal innovation can have a positive effect on general health which thus reduces mortality and death rate. This will automatically impact the productivity and the related costs of the health system in a long run increasing the economy of a country (Rosca et al., 2017).

In sum, RI provides an opportunity for sustainable growth as new markets can be created and a large customer base can be reached. In addition, it is observed that RI can indirectly have an impact on a sustainability level by affecting the environment, the social environment and the economy. However, the level of performance differs per innovation and thus per type of RI. In order to come up with a performance measurement framework on a financial, product and sustainability aspect, different methods will be used that are explained in the next chapter.

2.6 Summary chapter 2

In short, this chapter provided a background of the concept of RI which is the foundation of this thesis. First, the concept of RI is discussed and its development over the years. Initially, RI was observed to be a market process in which an RI is an innovation that transfers from an ECM to a DCM and therefore, RI was observed to be a case of adoption. This definition was expanded or reformed in which RI was defined as a combination of a product innovation and a market process which means that the an RI is designed for an ECM rather than adopted first in an ECM. However, it remains difficult to distinguish RI from other types of resource-constrained innovation. Therefore, Von Zedtwitz et al. (2015) recognised that RIs are processes consisting of four phases and reversal flow in between these phases will determine whether an innovation is an RI. This led to the development of ideation-based and development-based RIs and broader definition of RIs that is used in this thesis: "any type of global innovation that, at some stage during the innovation process, is characterized by a reversal flow of innovation from a developing country to an advanced country, and that is eventually introduced to an advanced country's market" (Von Zedtwitz et al., 2015, p. 17).

The definition of Von Zedtwitz et al. (2015) thus allows the distinction of RI from other types of resource-constrained innovation. However, RIs share some characteristics with frugal innovation, cost innovation and good-enough innovation. Therefore, there are examples of some frugal innovations, cost innovations and good-enough innovations that become RIs but this is not always the case as ideation-based and development-based RI can be different. Based on the definition of innovation (Appendix A), the definition of RI and the relation to other types of resource-constrained innovations, the categorisation used in thesis is provided in section 2.4.

Regarding RI in the healthcare sector, different studies have been performed. For example, DePasse & Lee (2013) were able to discuss the diffusion of RIs and Tombini Wittman et al. (2018) identified the different barriers and facilitators companies experience in the practice of RIs. Hereafter, the relevance of studying RI is discussed in section 2.6 as RI does not only provide economic value for the company producing RIs but it also provides socio-economic value to the community. In addition, RI is observed to be a strategy that could result in new product innovations which can also provide economic value. Finally, RIs are not only relevant in the context of socio-economic value but RI can also have environmental and social implications.

3 Research methodology

Chapter overview

This chapter provides the main methodologies that will be used in order to achieve the objectives mentioned in the introduction. It presents the principles of the methodologies and how these methodologies will aid in answering the sub-questions and main research question.

Section 3.1 starts with a general introduction to research methodology. Section 3.2 discusses the literature review that will be used in order to determine how the performance of innovation can be measured. Section 3.3 displays the interview that is used in order to answer sub-question 2. Section 3.4 described the analysis method that is used to analyse the interview data

3.1 Research methods

In order to answer the questions that were proposed in the introduction of this thesis, different research methodologies have to be used. The first sub-question is a literature based question and therefore literature research methods are required. The second question requires interview methods as expertise is required to determine how the performance of RI can be measured and which method is useful. Hereafter, case studies are required to determine the performance of different types of RI. In order to determine the performance both the measurement tool that is determined by the first and second sub-question and interviews will be used. These different research methodologies will be discussed and their advantages and disadvantages will be mentioned.

3.2 Literature review

Literature reviews are more relevant than ever with the increasing amount of research (Snyder, 2019). In order to deal with this increasing amount of research, literature reviews can thus be used as a more or less systematic way of collecting research (Snyder, 2019). In addition, the contributions to knowledge can be distinguished by performing periodic reviews which will help in evaluating arguments regarding the evolution of a specific research field (Denyer & Tranfield, 2009). Furthermore, literature reviews could play an important role in creating and building bodies of knowledge that can be used as information for policy and practice (Denyer & Tranfield, 2009).

As with other types of research methodologies, literature reviews can be divided into qualitative research and quantitative research (Snyder, 2019). Qualitative research aids in the interpretation of the concepts and content in the literature. By interpretation of previous research, new understandings can be uncovered which can lead to the development of a new theory (Seers, 2015). Quantitative research on the contrary is aimed at the analysis of numerical data by using statistical methods to evaluate the literature (Oh & Gastmans, 2015).

In order to answer sub-question 1, a qualitative literature review will be used due to the fact that it allows the assessment of the different performance measurement tools that are used for innovation. This literature review will be performed in four phases. In the first phase the selection criteria for the articles is determined. The criteria for an article to be selected are listed in table 3-1. In the second phase, a couple of articles or papers will be selected from the found articles. In order to select an article, the title will be analysed. If assumed to be useful, the abstract will be controlled before reading the conclusion of the article. It is important to note that Google Scholar provides a lot of hits and will mainly be used for the search terms that consists of more words or if Scopus does not provide any articles.

In the third phase, it will be determined how the different articles will be used to produce an appropriate analysis. In the case of this literature review, descriptive information on the article will be mentioned and the main findings are displayed. These findings will be assessed based on their relevancy towards the concept of RI. The fourth phase consists of writing the review and distinguish between which metrics are useful to take into account for the performance measurement framework of RIs.

Table 3-1 Search criteria for the qualitative systematic literature review

	Included	**Excluded**
Document type	Articles and reviews in peer-reviewed journal Conference paper	Presentations Work-in-progress documents Patent
Year of publication	1990-now	Before 1990
Language of the article	English	Non-English
Search terms	Innovation AND “performance measurement” Innovation AND “performance indicators” Innovation AND “sustainability performance” Innovation AND “Financial performance” Innovation AND “healthcare” AND “performance” Innovation AND “sustainability performance measurement” “Reverse innovation” AND performance “Frugal innovation” AND performance “Frugal innovation” AND “performance measurement”	-

Search terms	"Product innovation" AND "Performance measurement" "Product innovation performance"	
Databases	Scopus, Google scholar	-
Citations	>20 In the case of recent articles this threshold will be re-evaluated	

3.3 Interview performance measurement

As mentioned in the introduction, the second sub-question is aimed at determining what types of performance measurement metrics are used in current practices of RI. Thus in order define a performance measurement framework of RI, knowledge from literature can be combined with knowledge from current practices of RI. In order to acquire this knowledge interviews will be used. The interview will take place in an online environment due to the Covid-19 pandemic.

3.3.1 Data collection on examples of RI

In order to find interviewees, examples of companies producing RIs have to be identified first. In order to find examples of RIs, literature on RIs will be used. Additionally, social media can be used to search for terms as 'trickle-up', 'blowback' or 'reverse innovation' which could lead to the identification of more examples of RI.

Next to the use of social media to find new examples of RI, innovations in the healthcare sector that are mentioned in the literature could be a weak or strong RI if one of the ideation or development phase took place in a ECM (Von Zedtwitz et al., 2015). This is important to note due to the fact that innovations in the healthcare sector that first got a foothold in a DCM and then transferred to an ECM can still be an RI.

In addition, Google scholar and Google news will be used in order to find examples on RI in the healthcare sector. For example, "Reverse innovation" AND Healthcare can be used on google news to find recent news articles on the most recent cases of reverse innovation. Furthermore, articles on Google scholar contain cases of RI that are already used in research. In order to select cases, an example of RI has to fulfil a couple of criteria.

First, the innovation has to be a product innovation in order to categorise which type of RI is dealt with. Second, the innovation has to be healthcare product which could either be a machine used in hospitals but also medicines or products that are used at home improving the health of social groups. Third, the product has to be sold in multiple markets in order to match the definition of Von Zedtwitz et al. (2015). Thereafter, it has to be identified if the product is either a weak RI or a strong RI by determining which of the four phases took place in an emerging country or in a developed country. Table B-1 in appendix A displays the examples of RI that are found in literature and on social media. Furthermore, the source is mentioned and if possible, it is determined whether the innovation is a weak or strong RI.

3.3.2 Interview

Now that more examples of RI are identified, interviewees with the right knowledge have to be found. In order to be selected for an interview, the interviewee has to fulfil a couple of criteria. First, the

interviewee needs to work for a company producing RIs as classified by Von Zedtwitz et al. (2015). Second, the interviewee needs to have five years of experience in the company he/she is working for and five years of experience on organising for RI. Second, the interviewee needs to have knowledge about the RIs of the company, the innovation strategy of the company and the performance metrics they use. Therefore, the interviewee needs to have a senior position in innovation management of the firm.

Before the interview, an email will be sent to the interviewee with a general introduction and the questions that will be asked during this interview (Appendix B). This interview will be semi-structured (Appendix C) interview and judgment sampling is used to find the interviewees. Judgment sampling is method in which the choice of subjects is based on who are most advantageously placed or who are in the best position to provide the knowledge that is required (Sekaran & Bougie, 2016). For this research, it was assumed that only a limited number of people have the knowledge on RI and performance measurement that is required for this research. Therefore, judgment sampling was used to select the interviewees that have knowledge on both RI and performance measurement. Finally, in table 3-2 the interview procedure that will be used for this research is displayed.

Table 3-2 Interview procedure on performance measurement of RI practices

Purpose	Gather knowledge on performance measurement
Duration	1 hour
Sampling technique	Judgment sampling
Data type	Qualitative data
Setting	Video meeting (Microsoft Teams or Skype)
Recording	Audio
Verification	Transcript

Based on the found examples of RI and the selection criteria, 4 interviewees have been found. Table 3-3 display for which company the interviewees work, their functional background, their role in the company and the years of experience in this company. Furthermore, the table displays the order of the interviews which means that the interview with GE was conducted first and the interview with Siemens was conducted last. Finally, the interviewee from Roche indicated that in email conversation that their company is not pursuing RI directly and therefore, the questions for Roche where changed.

Table 3-3 Interviewees performance measurement

Company	Functional background	Role in enterprise	Years of experience
Siemens	Product manager	Product manager	15+
Roche	Health consultant	International product manager	10+
Philips	Business development	Global portfolio management	10+
GE	Deputy manager	Global product manager	10+

3.4 Data analysis

In order to analyse the data obtained with the use of interviews, the software of Atlas.ti will be used. This software will analyse the difference and the similarities between the different interviews that are conducted. First, the data of the interview will be used to find out how companies observe RI and what metrics they use to measure the performance of RI. By answering those questions, the second sub-question can be answered. In order to answer the third sub-question, a comparison between literature and current practices can be made but also between the different companies pursuing RI. Both the

similarities and the differences can then be used to design a performance measurement framework for RI.

As mentioned, Atlas.ti will be used to analyse the qualitative data that is obtained from the interviews. The analysis of the data is more than using the software of Atlas.ti as it consists of five phases that occur iteratively (Yin, 2015). First, the database needs to be compiled which represents conducting the interview and making a transcript of the interview. The second phase consists of disassembling the interview data using the coding of Atlas.ti. This coding process is iterative as new codes can be formed during the analysis of an interview that can be used on other interview and so forth.

Third, the disassembled data is reassembled in different clusters in which the work of the second phase is also reviewed in order to improve the accuracy of the coding process. Furthermore, it is important to note that a code can be in different clusters and different clusters can thus overlap. Fourth, the different codes and its clusters are interpreted in the fourth phase of the analysis and finally, a conclusion is formed based on the previous phases (Yin, 2015).

3.5 Summary Chapter 3

In order to answer the research questions of this thesis, different research methods will be used. First, in order to answer first sub-question, a literature study has to be performed. A qualitative literature study is observed to be the most suitable method as it allows assessment of the different performance measurement tools that are currently used. Based on the assessment of the different performance measurement tools, the most suitable methods can be selected which can be used for the performance measurement framework.

In order to answer the second and third sub-question, interviews will be used. The interviews will provide knowledge on what types of metrics are used in current practices of RI and what the performance is of current practices of RI. However, in order to find interviewees, examples of RI have to be found. Different sources ranging from social media to news articles are used to find existing but also new examples of RI. Hereafter, the different criteria for the interviewees are set and semi-structured approach is used to allow discussion and open input from the interviewee. In the appendix the list of RI examples and information regarding the interview and the interview questions is displayed.

4 Performance measurement: a literature review

Chapter overview

This chapter contains the systematic literature review on performance measurement on both companies. The methods and frameworks that are used to measure performance are assessed. Based on this assessment a concept for a measurement framework will be designed.

Section 4.1 starts with a short introduction to performance measurement. Section 4.2 will produce an overview of the history of performance measurement. Section 4.3 will discuss the different methods that are used for financial performance measurement. Section 4.4 will discuss the different methods to assess product innovation performance and section 4.5 discusses sustainability performance measurement. Finally, section 4.6 provides a summary of the findings in this chapter.

4.1 Performance measurement: an introduction

Business environments are nowadays continuously changing resulting in a tough life for all businesses. The main reason that the business environment is continuously changing is a combined pressure of globalization, technological advancements, interconnectivity and economic liberalization (Yadav et al., 2013). Due to these changes in the business environment, value creation and sustaining competitive advantage became the main emphasize of the business ecology. This led to the development of performance measurement in combination with management that changed over the past years (Yadav et al., 2013). These changes in performance measurement can be assigned to the enormous increase in research on performance measurement (Taticchi, Tonelli, & Cagnazzo, 2010).

Initially these performance measurement systems were aimed at financial performance such accounting metrics, variance reports, the static view of costs and profit and loss statements (Quinn, Thomas, & Penny, 1990). This traditional view of financial performance measurement was highly criticized as it did not take into account other non-financial aspects such as strategic and operational quality perspectives (Bititci, 1994; Hayes & Abernathy, 1980). This led to the revolutionary development of the balance scorecard (BSC) by Kaplan & Norton which was recorded as one of the 75 most influential ideas of the twentieth century (Bible, Kerr, & Zanini, 2006; Srimai, Radford, & Wright, 2011). However, the BSC also has some shortcomings which led to the development of different types of performance measurements (Ahn, 2001; Nørreklit, 2000).

Furthermore, it is important to distinguish performance measurement frameworks aimed at companies and performance measurement frameworks aimed at single innovation products. This literature review provides an overview of the different metrics that can be used to assess the performance in the context of a financial perspective, a product innovation perspective and a sustainability perspective. In addition, the strengths and weaknesses of different types of metrics are discussed and based on these strengths and weaknesses, different types of metrics are ought to be more suitable to assess the performance of RIs.

4.2 The history of performance measurement

As mentioned in the previous section, early stages of performance measurement were based on cost-accounting. However, this method does not take into account any non-financial aspects and furthermore this method was ought to be inadequate and misleading which is due to the fact that cost-accounting does not trace the cost of products, activities, processes and the cost of quality (Bititci, 1994). The DuPont corporation changed this mind-set in the early 1920s developing the return on investment calculations. The development of this financial ratios started a new era of performance measurement in which a lot of new financial ratios were designed (Figure 4.1) (Yadav et al., 2013).

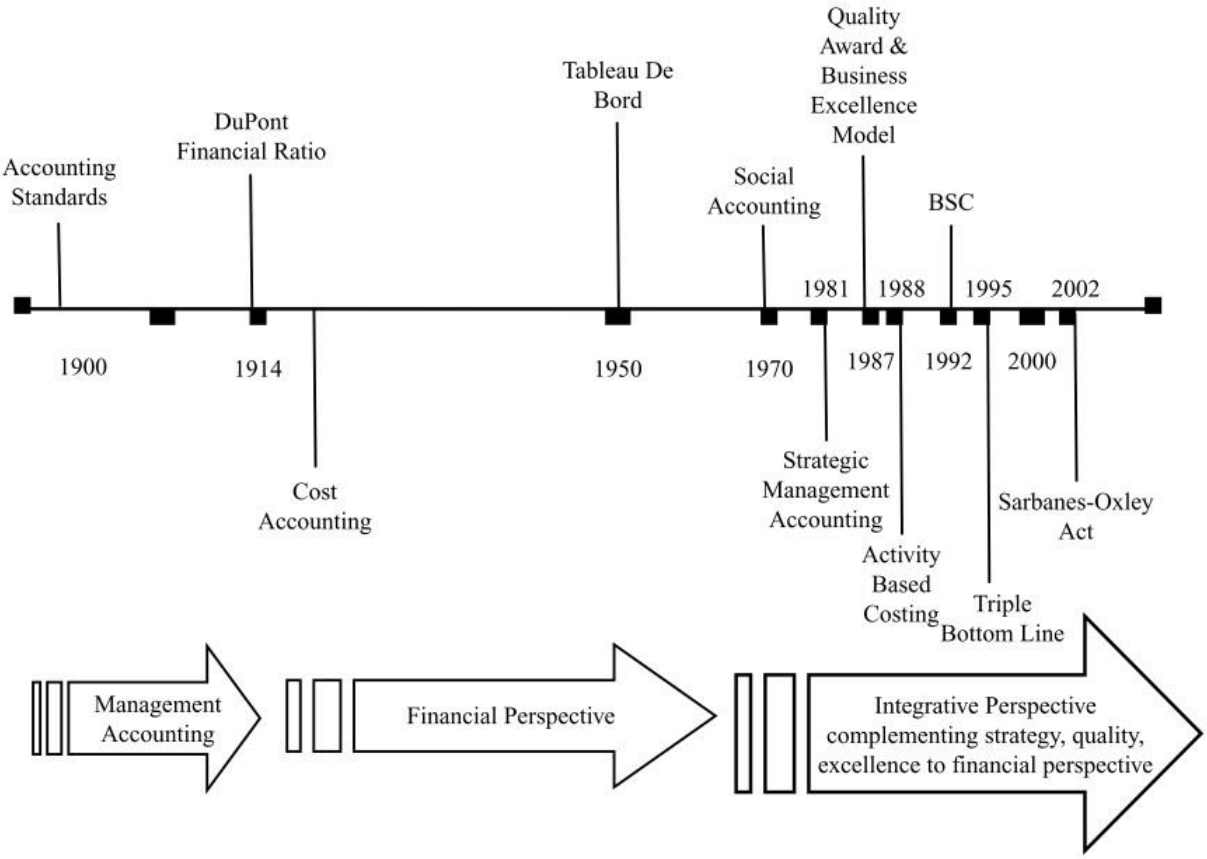

Figure 4.1 The history of performance measurement. From *Performance measurement and management frameworks: Research trends of the last two decades* by Yadav et al. (2013. p.950).

However, these financial ratios still did not take into account any societal consequences of innovation and therefore, the Tableau de bord was designed by French engineers. This new performance measurement method was the first to take into account both financial and non-financial metrics which led to the development of social accounting, strategic management accounting and activity based costing that also supported the importance of other aspects beyond the financial metrics (Epstein & Manzoni, 1997; Srimai et al., 2011; Yadav et al., 2013). However, it was not until 1992 before there was a revolution in performance measurement methods which was brought forward by Kaplan & Norton.

This change and revolution was announced a year before the development of the BSC by Eccles (1991). In his performance measurement manifesto, it was announced that in five years, all companies had to redesign their performance measurement systems (Eccles, 1991). In order to do so, companies had to

shift their main focus from treating financial metrics as a foundation to treating them as one of a broader set of metrics. Furthermore, Eccles (1991) observed that companies were already tracking quality and other nonfinancial metrics for years but they provided these metrics not with an equal status in comparison to the financial metrics. Additionally, Eccles provided numerous reasons for the revolution of performance measurement.

First, measuring financial performance gives an indication of the consequences of yesterday's decision instead of indicating tomorrow's performance. Therefore, new metrics including customer satisfaction and market share were identified to serve as leading indicators (Eccles, 1991). Second, large manufacturers and service providers are using quality as a strategic weapon and impose quality requirement on their suppliers (Eccles, 1991). Third, customer satisfaction becomes more and more important and this concept became the highest priority of manufacturing companies requiring a clear measurement tool. Fourth, competitive benchmarking received increasing interest which gives managers a methodology based on nonfinancial metrics and it has a changing effect on managerial mind-sets. Finally, information technology drives the revolution of performance measurement by increasing the amount of information that can be stored (Eccles, 1991).

These reasons thus led to the development of the BSC which sets goals for different perspectives and how to measure these goals (Kaplan & Norton, 1992). For example, a goal could be to produce new products and a suitable metric could be the percent of sales from new products. In this way, companies will be able to look forward instead of backward (Kaplan & Norton, 1992). This BSC was therefore integrated within a performance management system (PMS) which is a dynamic model that manufacturing companies used to design and fulfil long-term objectives.

In the years after the development of the BSC, different researchers aimed at updating BSC as well as discussing other issues with different types of PMS. For example, some researchers argue that the BSC and PMS does not take into account other stakeholders (Neely, Adams, & Crowe, 2001; Srimai et al., 2011; Sureshchandar & Leisten, 2005). This led to the integration of social and environmental perspectives within the BSC and the PMS (Figge, Hahn, Schaltegger, & Wagner, 2002). The integration of these perspectives is more in line with the concept of RI and should be taken into account for the production of a performance measurement framework.

Next to the sustainability alternatives of the BSC, Chytas et al. (2011) combined the use of a BSC with key performance indicators (KPIs) to produce a proactive BSC. In this proactive BSC, a methodology is designed to draw causal representation of these KPIs, simulates the KPIs and quantify the impact of every single KPI which will result in a performance adjustment (Chytas, Glykas, & Valiris, 2011).

Some researchers went ever further in their development of new performance measurements framework by either producing a multi-dimensional framework or a new scorecard called the strategy game-card that highlights both sides of performance which are the enterprise perspective and the customer perspective (Maltz, Shenhar, & Reilly, 2003; Sushil, 2010). This development also led to the use of performance measurement systems for service providers (Yadav et al., 2013).

These performance measurement systems mentioned above are mainly aimed at enterprise performance as the dependent variable (Alegre, Lapiedra, & Chiva, 2006). Despite the fact that research is mainly aimed at enterprise performance, innovation performance can be observed to be an intermediate variable between a firm's business process and its general performance (Alegre et al., 2006). Additionally, previous research displays that there is a positive link between innovation

performance and the performance of a single firm (Atuahene-Gima, 1995; Yeoh & Roth, 1999; Zhang & Doll, 2001).

The study of product innovation performance is relatively new compared to firm performance measurements and as with the performance measurements methods for firms in general, product innovation performance was expanded with the sustainability concept as well (Levänen et al., 2015; Shan & Khan, 2016). In these articles, sustainability indicators are set up based on the sustainable development goals of the United Nations (Levänen et al., 2015; Shan & Khan, 2016). However, these methods are only aimed at the sustainable impact of RI and do not consider product innovation performance and financial performance.

Therefore, a combination of measurement methods based on financial performance, product innovation performance and sustainability performance should be produced in order to cover all aspects of RI. Furthermore, it is important to note that the most methods such as the BSC are aimed at tomorrow's performance. This means that measurement metrics are used to validate the different goals set by a company and is thus a form of management. In this research, the focus is on the different performance metrics that are currently used to assess the performance of different companies. However, it is key to know that the metrics that are used, are based on the goals and objectives of a specific company. Therefore, it is important to understand the goals of companies pursuing RI.

4.3 Financial performance

As mentioned in section 1.3 of this research, the first metrics that are used are aimed at the financial performance of a company pursuing RI. This is due to the fact that financial performance reflects the well-being of a company. Next, despite the fact that financial performance metrics are aimed at yesterday's performance instead of tomorrow's performance, these metrics are the metrics for assessing the effectiveness of management decisions. Furthermore, companies aimed at new product development often use financial performance metrics to assess which project to continue and which project to drop (Chiesa et al., 2009).

4.3.1 Accounting-based metrics

As with the methods of performance metrics, financial performance measurement also changed over the years which resulted in the development of a lot of different metrics (Venanzi, 2012). First, accounting-based metrics of performance were used such as the return on investment (ROI), return on assets (ROA), the return on sales (ROS) and the return on equity (ROE) (Aguilera-Caracuel & Ortiz-de-Mandojana, 2013; Gunday, Ulusoy, Kilic, & Alpkan, 2011; Zahra, 1993; Zahra & Covin, 1995; Zahra & Pearce, 1989).

The foundation of these accounting-based metrics is the net profit of a company or a specific product. By dividing the profit by either, the assets, the sales or the equity, a ratio is calculated that shows the return of either, the assets, the sales or the equity (Masa'deh, Tayeh, Al-Jarrah, & Tarhini, 2015). Furthermore, the growth of these numbers can be taken into account in order to determine the financial performance growth of a company.

Despite the fact that these methods received criticism over the years, these key figures are still used to determine the financial performance of a company or an investment as these methods also provide

some advantages (Venanzi, 2012). First, these accounting based metrics provide information on the profitability of the firm or a product. Therefore, financial accounting metrics reflect on what has happened or can be used to determine which project to pursue (Masa'deh et al., 2015; Venanzi, 2012). Second, the accounting-based metrics provide information on the firm's internal efficiency (Cochran & Wood, 1984; Orlitzky, Schmidt, & Rynes, 2003)

However, in recent years the criticism on the accounting-based metrics increased which is based on three different points. First, the metrics are based on earning figures that can be computed using alternative accounting methods. This means that a change in method could result in a change in the earnings but does not directly change the company's cash flow and its economic value (Venanzi, 2012). Therefore, a comparison between different firms and years are not reliable and managers can manipulate data by decreasing value-creating spending on for example advertising to meet different benchmarks (Graham, Harvey, & Rajgopal, 2005).

Second, the accounting-based metrics are not aligned with the goal of maximizing shareholder wealth. This means that maximizing earnings or returns does not imply a maximization of the shareholders' value. By maximizing earnings, the amount of capital invested is not taken into account and by considering a maximization of the accounting rates, some projects are rejected based on a ROI no matter what long-term value of the project is (Venanzi, 2012). However, this second reason is less applicable to the RI concepts discussed in this research as the objectives of RI is more than maximizing shareholder wealth.

The third reason for criticism on the accounting-based metrics is based on the term of these accounting-based metrics. Activities that increase the long-term value such as new product development, marketing spending and aggressive pricing can result in a decrease of ROI on the long-term (Venanzi, 2012). Therefore, ROI is focussed on short-term earnings instead of long-term value which thus indicates that projects that provide long-term value can be discarded on the basis of ROI (Al-Matari, Al-Swidi, & Fadzil, 2014; Venanzi, 2012).

4.3.2 Value-based metrics

Due to the increase of criticism on the accounting-based metrics, new financial performance metrics are developed such as the economic value added (EVA), the cash flow return on investment (CFROI), the market value added (MVA), the shareholder value added (SVA), the economic margin (EM) and the cash flow value added (CVA) (Venanzi, 2012). These financial performance metrics are value-based instead of accounting-based but similar to the accounting-based metrics, these methods also have their advantages and disadvantages.

The first method is the market value added method which measures the difference between a company's fair market value and the economic book value of capital employed (Weissenrieder, 1998). However, this method is focused on the current value of the company in the market and therefore, it appears to be inadequate for measuring any value creation by the company (Weissenrieder, 1998). Therefore, the MVA is different in concept than EVA, SVA, EM, CVA and CFROI as it does not present a value added of today's business of a company but also the net present value of the company's future business (Weissenrieder, 1998).

The other value-based metrics are more or less based on the concept of residual income (Venanzi, 2012). Residual income is the after-tax operating profits less a charge for invested capital and this thus

reflects the firm's weighted average cost of capital (Worthington & West, 2001). The concept of EVA is almost similar to the residual income but it consists of a few accounting adjustments to convert the accounting numbers to economic numbers. This means that in order to calculate the EVA, the net operating profit after tax has to be lessened by the invest capital times the weighted average cost of capital (Arabsalehi & Mahmoodi, 2012).

The third value-based metric is the CFROI which is a modified version of the internal rate of return and based on four inputs: the gross investment, the gross cash flow, the expected life and the expected value of assets (Damodaran, 1999). From the CRFOI, the fourth value-based metrics SVA can automatically be derived by multiplying the spread between CFROI and cost of capital with the inflation adjusted gross investment (Venanzi, 2012).

The fifth value-based metric is the SVA which measures the value creation of a strategy and therefore this metric is used in backward and forward-looking. However, measuring the historical performance expresses the difference between actual and expected SVA. Next, this method takes a lot of key-factors into account to determine the performance which differ from growth of sales to tax rate (Venanzi, 2012).

Finally, the sixth value-based metric is the EM which is based on three inputs: operating cash flow, invested capital and a capital charge. Therefore, this metric shares the most common adjustments to change the accounting data to economic data with the EVA but it adds depreciation and amortization in order to determine the cash flows (Venanzi, 2012).

These value-based metrics are often used as predictors of stock return and several studies have examined claims that these value-based metrics are better predictors of stock returns than the accounting-based metrics (Venanzi, 2012). For example, that stock returns are more highly correlated with average EVA than average ROA, ROS or ROE (Lehn & Makhija, 1997). This was also underlined by Chen and Dodd (1997) as improving EVA performance is associated with a higher stock return. However, this correlation is not as strong as suggested in earlier studies as there is still a large percentage of unexplained variation in stock returns (Chen & Dodd, 1997).

Despite the fact that these value-based metrics are better predictors of stock returns, these value-based metrics are not often used in business planning or as a performance metric in incentive plans (Ittner & Larcker, 1998). In addition, many companies only used these value-based metrics in annual incentive plans rather than long-term planning (Venanzi, 2012). The reason that these value-based metrics are less used is also due to the fact that these methods also have some weaknesses.

First, these methods are known for some shortcomings in the calculation of these metrics as there might be some accounting and inflation distortions. Furthermore, there is an inconsistency with value creation as for example, CFROI suffers the hurdle rate problem which occurs when a company sets an acceptable rate of return and assess performance based on the achieved rate (Venanzi, 2012). Next, these value-based metrics are ought to be inadequate in managerial compensation. For example, the EVA was criticized as being too complex to use by managers and the same applies to the CFROI which provide some difficulties for managers linking the improvements in cash flow that are needed to increase in the set targets (Venanzi, 2012). Finally, these metrics are more or less used for the determination of stock return rather than measuring historic performance of a company. Therefore, these value-based metrics are not only complex to calculate, they have difficulties providing a backward-looking perspective towards performance.

4.3.3 Market-based metrics

Next to the accounting-based and value-based metrics, market-based metrics have been developed to determine an organisation's financial performance. These market metrics are commonly used by investors to determine in which firm an investment can be made. Therefore, market-based metrics describe how well a firm is financially performing in relation to the price of its shares, the dividends or the numbers of shares (Masa'deh et al., 2015). This automatically implies that in order to assess the financial performance of a firm, they have to be public limited company. Similar to the accounting-based and value-based metrics, market-based metrics also have their advantages and disadvantages.

An example of a market-based metric is the price-to-earnings ratio which compares the current stock price of the firm with its earnings and thus an increase in this ratio leads to higher expectations of the firm's future profitability. However, this metric is a misalignment for performance measurements as it divides the present value of a stock with historical earnings (Masa'deh et al., 2015).

A second market-value metric is the market-to-book ratio which can be calculated by dividing the company's market value of equity by the book value of the equity. This number is therefore easy to calculate and it clearly reflects the current market value of a company. However, there is no guideline for what the ratio should be and furthermore, this ratio indicates what the value of the company is in the market instead of providing information on the profitability of the firm (Masa'deh et al., 2015).

Third, the focus of some analysts and investors shifted towards other ratios and statistics that provide more information such as the cash flow per share. This ratio is aimed at measuring the company's effort to acquire long term purchases. Therefore, an increase in cash flow to capital expenditure indicates that the company has financial flexibility to allow new investments in processes (Masa'deh et al., 2015).

Using these market-based metrics has a couple of advantages over accounting-based metrics as the market-based metrics are less susceptible to managerial manipulation of the accounting numbers (Chakravarthy, 1986; Mcguire, Sundgren, & Schneeweis, 1988). Furthermore, the market-based metrics represent the evaluations of the firm's ability to make future economic earnings rather than evaluating the past performance of the company (Mcguire et al., 1988). Next, the market-based metrics incorporate all relevant information of a company and therefore they are not limited to a single aspect of a company's performance (Gentry & Shen, 2010).

However, in order to use the market-based metrics, a company has to be a public limited company with stocks on the market to buy for investors. Furthermore, some methods of market-based metrics contain a misalignment by comparing present values of a stock with historical accounting numbers. In addition, market-based metrics are investors' evaluations of the financial performance of a company and therefore focusing solely on these metrics may not be sufficient (Mcguire et al., 1988). Next, these market-based metrics reflect factors that are not in control by managers such as inflation and they cannot be used to assess the performance of a single division or a product (Venanzi, 2012). Finally, the market-based metrics are prone to investors' expectations which can differ from the managers' rationale and they tend to aggregate information in an inefficient manner (Venanzi, 2012).

4.3.4 Comparison of financial performance metrics

These three different financial performance metrics all have their own strengths and weaknesses and in order to determine the most suitable metric to assess the performance of RI, this section will provide a comparison of the three methods. Table 4-1 summarizes the different strengths and weaknesses of the different types of metrics.

Based on these strengths and weaknesses, both accounting-based and value-based metrics are determined to be the most suitable metrics to assess the performance of RIs as these metrics allow the measurement of a single aspect or product of the company. Therefore, the performance of an RI can be measured without taking into account other parts or aspects of the company which is the case for the market-based metrics that take into account the company as a whole. Furthermore, the accounting-based metrics can be used to determine the profitability of the RI products and projects which is the main goal of this research.

Furthermore, accounting-based metrics are known as a metric of short-term financial performance while value-based metrics are aimed towards the long-term perspective and therefore, a combination of both should cover both the short-term and long-term performance (Venanzi, 2012). In addition, accounting-based metrics are backward looking while most value-based metrics are forward looking and therefore a combination of both methods will provide a forward and backward looking approach (Ebaid, 2011; Venanzi, 2012). Next, a combination of both metrics can prevent managerial manipulation in the accounting-based metrics.

Key Findings

- There are three different types of metrics: accounting-based, value-based and market-based.
- Value-based and market-based metrics are aimed at long-term planning while accounting-based metrics are aimed at short-term planning.
- Value-based metrics can be used as both a forward looking and backward looking approach while the market-based metrics are used as a forward looking approach and accounting-based metrics as a backward looking approach.
- Accounting-based metrics are susceptible to managerial manipulation.
- Market-based metrics can be misaligned.
- A combination of both accounting-based and value-based metrics covers all strengths and weaknesses.

Table 4-1 Strengths and weaknesses of financial performance metrics

	Accounting-based metrics	**Value-based metrics**	**Market-based metrics**
Foundation	Net profit of a company	More or less based on the concept of residual income which is the after-tax operating profits less a charge for invested capital	Based on market figures such as the stock price, the amount of shares and dividend.
Examples	Return on assets (ROA), return on sales (ROS) and return on equity (ROE)	Market value added (MVA), economic value added (EVA), cash flow return on investment (CFROI), shareholder value added (SVA), economic margin (EM) and cash flow value added (CVA)	Price-to-earnings ratio, market-to-book ratio and cash flow per share
Strengths	- Provides information on the profitability of the firm - Can support decision making - Provides information on the internal efficiency of a firm - Represent the past performance of a firm, product or project	- Provides a clear indication of stock return - Can be used as both a backward looking and a forward looking approach. However, backward looking is difficult - Can be used for long-term planning - Are not susceptible to managerial manipulation	- Represent the firm's ability to make future economic earnings - Can be used as a forward looking approach - Provide a clear indication of stock return - Are not susceptible to managerial manipulation - Are not limited to a single aspect of the company
Weaknesses	- Are susceptible to managerial manipulation - Only aimed at short-term performance of the firm - Are not aligned with maximizing stakeholder value	- There might be some accounting and inflation distortions - Difficult to use for historic performance - Are inadequate in managerial compensation - Are complex in use	- Only works for public limited companies - Some metrics contain a misalignment by comparing present values to historical values - Some factors in these metrics are not in control by managers - Are prone to investors' expectations which can differ from managers' rationale - Aggregate useful information in an inefficient manner

4.4 Product innovation performance

The second performance measurement perspective that is taken into account in this research is the product innovation performance due to the fact that an increased product innovation performance is positively linked to overall firm performance (Capon et al., 1990; Garcia & Calantone, 2002). Additionally, product innovation will lead to higher financial performance increasing the well-being of the company and it has a large impact on the competitive position of the firm (Alegre et al., 2006; Fernandes et al., 2013; Löfsten, 2014). Similar to financial performance measurement, product innovation performance changed over the years which resulted in the development of different product innovation performance metrics.

4.4.1 A process approach

One of the first methods aimed at measuring product innovation performance was the innovation audit designed by Chiesa, Coughlan & Voss (1996). In order to develop this audit, four core processes of innovation were identified: concept generation, product development, process innovation and technology acquisition. In addition to these four core processes of innovation, three enabling processes were identified: leadership, resources and systems and tools. For each of these seven processes, different metrics were used to assess the performance of each of these processes.

What is interesting to note is that the first two processes of this audit model by Chiesa et al. (1996) are identical to the phases that are identified in the typology of Von Zedtwitz et al. (2015) and therefore, assessment of these phases could help in the formation of a performance measurement framework of RI.

First, concept generation performance can be assessed by measuring the number of new product ideas that are generated, evaluated and developed but also by measuring customer satisfaction including the degree of product variety and the number of designs meeting customer needs (Chiesa, Coughlan, & Voss, 1996). Furthermore, the average product life cycle length and the product planning horizon are metrics of concept generation performance.

Second, product development can be assessed by a couple of metrics including the quality of the innovation and the overall functional performance (Ellison, Clark, Chew, & Fujimoto, 1995; Voss, 1992). Next, the speed and the engineering/design performance are part of the product development performance and again these three dimensions all have their own separate metrics. For example, speed is measured by the concept to cycle time, the development time and the total time containing both the concept to cycle time and the development time (Griffin, 1993). Product performance on the contrary consists of costs including unit costs, production costs and development costs but also technical performance and product quality (Chiesa et al., 1996). These metrics are also important for producing healthcare innovations as for examples cost effectiveness has emerged as a basic tool for evaluating healthcare practices (Weinstein, 1996).

Due to the fact that the innovation audit of Chiesa et al. (1996) covers a lot of different processes, different types of companies were able to use the tool for the area they wish to evaluate. Furthermore, the audit tool was helpful in defining different metrics that were needed in the future. Finally, using the audit tool led to the start of new actions in order to increase the performance of a specific performance.

The audit tool of Chiesa et al. (1996) also had some weaknesses as the collection of data for using the metrics was observed to be difficult and complex. Next, the auditing should be performed by a team where possible as it brings together a broad set of perspectives. Finally, performing this audit took 4 to 20 days on average indicating that it requires a lot of work that is difficult to do by managers (Chiesa et al., 1996).

4.4.2 Efficacy and efficiency

In contrast to the approach by Chiesa et al. (1996), Alegre et al. (2006) designed a new framework that was built on two dimensions of product innovation instead of measuring the performance of every single process (Alegre et al., 2006). These dimensions are the innovation efficacy which reflects the degree of success of a specific innovation and the innovation efficiency which reflects the effort that was required to achieve a certain degree of success (Alegre et al., 2006).

As efficacy reflects the degree of success of an innovation, it is important that the metrics in this dimension assess the economic objectives of the innovation. In order to find metrics, Alegre et al. (2006) used the measurement scales of the Organisation for Economic Cooperation and Development (OECD) which was designed to provide coherence among innovation studies resulting in a greater homogeneity and comparability in the field of innovation studies. These metrics are based on market performance such as the market share growth and therefore, some studies refer to the efficacy dimension as innovation market performance (Calantone et al., 1995; Valle & Avella, 2003).

The efficiency dimension is consistent with previous literature on new product development and is determined by the cost of project and the time needed to perform the project (Griffin, 1997; Valle & Avella, 2003; Zhang & Doll, 2001). It is important to note that both the time and the cost of the project can be measured objectively and subjectively and therefore, Alegre et al. (2006) took both into account developing the efficiency scale (Griffin, 1993, 1997; Valle & Avella, 2003; Zhang & Doll, 2001). The result of the measurement scale designed by Alegre et al. (2006) is displayed in table 4-2.

Table 4-2 Product innovation metrics. From *A measurement scale for product innovation performance* by Alegre et al. (2006, p.345).

Efficacy	**Efficiency**
Replacement of products being phased out	Average innovation project development time (an innovation project refers to the creation of a new product of new component)
Extension of product range within main product field through technologically new products	Average number of innovation projects working hours
Extension of product range within main product field through technologically improved products	Average cost per innovation project
Extension of product range outside main product field	Global satisfaction degree with innovation projects efficiency
Development of environment-friendly products	
Market share evolution	
Opening of new markets abroad	
Opening of new domestic target groups	

After designing the measurement scale, Alegre et al. (2006) performed different analyses to test the validity of the measurement scale. In this analysis, it was shown that efficacy and efficiency are complementary to each other and there is a substantial correlation between both dimensions. Therefore, managers should focus on both efficacy and efficiency in order to improve their product innovation performance. Furthermore, the validity analysis showed that the measurement scale has adequate convergent validity of the constructs. Next, the measurement scale is more easy to use in comparison to the audit tool by Chiesa et al. (1996).

However, due to the fact that the model designed by Alegre et al. (2006) is a measurement tool using the Likert marking system, it is a method that compares the performance of a single company with other companies in the market rather than a method that assesses the performance of the product innovation within the company. So in order to use the measurement scale of Alegre et al. (2006), the designed metrics have to be altered so that they can be used as stand-alone metrics instead of comparison metrics. Furthermore, the measurement scale of Alegre et al. (2006) consists of twelve different metrics and therefore the measurement scale might miss out on different aspects of product innovation performance. In order to prevent missing out on performance metrics, different metrics on product innovation can be added regarding the first two processes of the audit model by Chiesa et al. (1996)

4.4.3 Innovation capability

Another method measuring product innovation performance uses innovation capability as a foundation due to the fact that innovation capability displays the company's ability to produce new innovations to be competitive (Saunila & Ukko, 2012, 2013). However, measuring the performance of innovation capability remains a challenging task due to the fact that it is intangible (Albaladejo & Romijn, 2000). Therefore, innovation capability was split up in three different elements: innovation potential, innovation processes and the results of innovation activities.

First, innovation potential refers to the factors that are required to produce innovations. There are five different categories of innovation potential: leadership and decision-making, organization structures and communication, collaboration, organization culture and individual creativity (Saunila & Ukko, 2012). However, these factors are difficult to measure as some are still intangible and therefore, measuring innovation capability stays a complex task.

Second, innovation processes are already mentioned before in the measurement audit tool of Chiesa et al. (1996). Therefore, measuring innovation capability consists of measuring the performance of each process. However, Saunila & Ukko (2012) use five different elements instead of four in order to divide the innovation process. Some of these elements are similar to the phases of Chiesa et al. (1996) and therefore, the same metrics can be used. This thus will lead to a very difficult and complex approach of measuring performance.

Third, the results of the innovation activities are taken into account which can simply be measured by the amount of new products or services (Saunila & Ukko, 2012). Furthermore, the results of innovation can be defined similar to the concept of efficacy and therefore, the same metrics can be used.

In addition to the three elements that form the foundation of innovation capability, Saunila & Ukko (2012) linked these three elements to the four business performance metrics that were designed by Kaplan & Norton (1992) for the BSC (Figure 4.2) Increasing one facet of the innovation capability can

be a direct or an indirect cause for the increase in overall business performance. For example, an improvement in the performance of one of the elements of innovation capability could lead to a higher overall business performance.

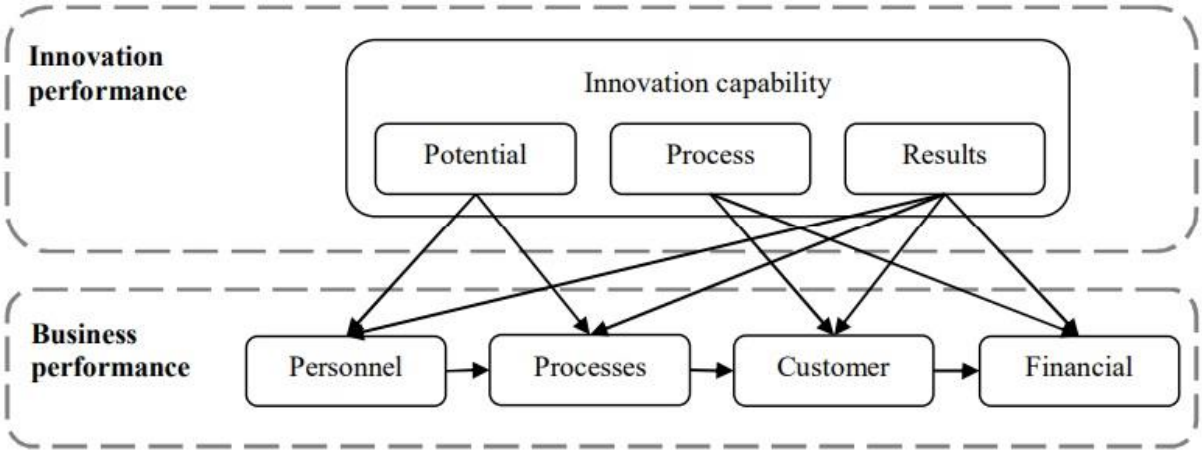

Figure 4.2 The different stages of performance measurement and their cause-effect linkages. From *A conceptual framework for the measurement of innovation capability and its effects* by Saunila & Ukko (2012, p.368).

The strength of assessing innovation capability is that there are new elements of which the performance is measured. Additionally, these elements can directly or indirectly influence the overall business performance and therefore, measuring and tracking the performance of these elements can be important in order to improve a company's overall business performance.

However, innovation capability remains an intangible concept that is complex to measure (Saunila & Ukko, 2012, 2013). Furthermore, by dividing this concept in three elements, the measurement becomes more complex and still consists of intangible metrics such as the measurement of creativity. Furthermore, performing the measurement of innovation capability will require a lot of time and work due to the fact that the three different elements have to be measured in depth in order to determine the company's innovation performance.

4.4.4 Research and development performance

Finally, product innovation is often linked to the performance of R&D activities and therefore measuring the performance of R&D can provide insights into the overall innovation performance. Furthermore, the effectiveness of R&D is ought to have an impact on the firm's overall performance (Birchall, Tovstiga, Chanaron, & Hillenbrand, 2011). This resulted in an increase in the interest in R&D performance measurement over the years but a lot of gaps still have to be filled as measuring R&D performance is a complex task (Birchall et al., 2011; Henttonen, Ojanen, & Puumalainen, 2015).

In the start of R&D performance measurement, R&D metrics were focused on results rather than behaviour and objectives (M. G. Brown & Svenson, 1998). This idea was altered by Nixon (1998) as his idea was that the R&D performance metrics should have a strategic orientation. Therefore, the indicators should be simple, have the ability to encourage change and it should take into account financial and non-financial perspectives (Nixon, 1998).

Hereafter, a couple of researchers stated that an effective measurement of R&D performance should include both quantitative and qualitative metrics (Bremser & Barsky, 2004; Pawar & Driva, 1999; Werner & Souder, 1997). Furthermore, the type of R&D and innovation, the dimensions of

performance and the unit of analysis are important factors in deciding which performance metrics to use (Chiesa et al., 2009; Hauser, Ding, Greenberg, & Matsuo, 1998; Pawar & Driva, 1999).

Despite the fact that these factors are of importance in deciding which types of metrics to use, previous studies on R&D performance took into account all four different perspectives of the BSC to determine R&D performance (Chiesa et al., 2009; Kerssens-van Drongelen & Bilderbeek, 1999; Lazzarotti, Manzini, & Mari, 2011). However, for this product innovation performance, the metrics focused on assessing the innovation and learning perspective are of main importance.

In order to measure the performance of R&D from an innovation perspective, the number of patents and the number of ideas are metrics that are currently used to assess the output of R&D (Chiesa et al., 2009; Kerssens-van Drongelen & Bilderbeek, 1999). Other metrics that assess the R&D innovation performance are for example the average product life cycle length, the number of innovations delivered by R&D, the number of products in development and the number of improvements suggestions per employee (Chiesa et al., 2009).

In addition to the metrics that focus on the outputs of R&D, Chiesa et al. (2009) also designed metrics focussing on the input and the process of R&D. Input metrics are for example the number of employees in the R&D department and the number of people with R&D management experience. Process metrics rather focus on the number of hours of staff training or the percentage of suggestions that are implemented (Chiesa et al., 2009).

Despite the fact that these metrics are clearly stated and easy to use, they do not really capture the value of product innovation performance regarding the efficiency of the processes that are carried out during product innovation. Furthermore, R&D performance metric focusses on all four perspectives of the BSC which results in a less in depth measurement of product innovation performance. Next, there is a lack of agreement in the measurement units of R&D performance and the metrics that are proposed to measure R&D performance cannot be used to measure the performance of innovation process of a single product (Lazzarotti et al., 2011). Finally, the measurement procedures on R&D performance are weakly validated (Lazzarotti et al., 2011)

4.4.5 Comparison of product innovation performance metrics

Over the years, different metrics were designed in order to measure product innovation performance. First, the audit tool by Chiesa et al. (1996) was designed in order to determine the performance of each phase of the innovation process which resulted in a complex measurement tool that covers a lot of aspects of the innovation process. Next, Alegre et al. (2006) took another approach to measure the performance of product innovation by taking into account two dimensions: efficacy and efficiency. Where efficacy focuses on the success of innovation, efficiency is complementary and focuses on the effort required to acquire this level of success.

Next, innovation capability and R&D performance were discussed. First, innovation capability performance measurement is complex as innovation capability is intangible. Second, R&D performance measurement was less focused on the efficiency of the product innovation process itself and it is difficult to measure the performance of the innovation process of a single product. Finally, table 4-3 displays the four methods and shows their strengths and weaknesses.

As a result of the strengths and weaknesses of these proposed methods and tools, a combination of the efficacy and efficiency approach and the process approach can be used to assess product innovation performance. However, in order to use the efficacy and efficiency method designed by Alegre et al. (2006), these have to be altered in order to use the method for measuring the product innovation performance of the company itself rather than comparing their performance directly to other companies. Due to the fact that this model only consist of twelve metrics, the measurement might miss out on different aspects of product innovation performance. In order to resolve this problem, the metrics on concept generation and product development are added as these two processes are taken into account for the identification of different types of RI. Finally, both methods are taking into account cost effectiveness which has emerged as an important tool within the evaluation of healthcare systems (Weinstein, 1996).

Key Findings

- Different approaches and methods can be used to measure the performance of innovation: process, efficacy & efficiency, innovation capability and R&D.
- Measuring innovation performance by using the process, innovation capability or the R&D approach is observed to be a complex task.
- Efficacy and efficiency metrics have an adequate convergent validity of the constructs.
- Innovation capability can be a direct or an indirect cause of improving the overall business performance
- R&D performance is aimed at overall company performance rather than assessing the performance of product innovation due to the fact that all four perspectives of the BSC are taken into account.
- For this research, the process approach and the efficacy & efficiency approach are ought to be the most suitable to measure product innovation performance.

Table 4-3 Strengths and weaknesses of product innovation performance metrics.

	Process-approach	**Efficacy & efficiency**	**Innovation capability**	**R&D**
Foundation	Four core processes of innovation and three enabling processes	The results of innovation and the effort required to acquire these results	Innovation potential, innovation processes and innovation results	The BSC forms the foundation of measuring R&D performance
Examples	Product quality, speed, engineering, average product life cycle.	Replacement of products, opening of new markets, average cost of an innovation project	Amount of new products, creativity performance, product quality	Number of patents, number of ideas, number of products in development
Strengths	- Can be used in different sectors and companies - Can lead to new actions in order to increase overall business performance - Helpful in defining new metrics	- Easy to use - Has adequate convergent validity of the constructs - Efficacy and efficiency are complementary	- New elements of innovation can be measured - These new elements can directly or indirectly influence overall business performance and therefore measuring them is important	- R&D metrics cover a lot of different aspects - Consists of both qualitative and quantitative metrics - Easy to use
Weaknesses	- The tool is difficult to use - A team is required to use the tool effectively as a lot of different perspectives are required - It takes a lot of time to use the tool and assess	- Is aimed at comparing your company with other competitors rather than assessing your own product innovation performance - Might miss out on certain aspects of product performance as it only consists of twelve metrics	- Innovation capability is an intangible concept which is complex to measure - Requires a lot of work and time in order to measure all elements in depth	- Has less focus on product innovation performance as it takes into account other perspectives as well - There is a lack of agreement on R&D performance metrics - The measurement procedures are weakly validated - Difficult to use for measuring performance of single innovation product

4.5 Sustainability performance

As mentioned in chapter 2, sustainability is one of the drivers of innovation and therefore, sustainability performance metrics are nowadays used during product development to secure a strategic intention that is aimed at a better environmental footprint (Cobb et al., 2009; Kennedy et al., 2017; Provasnek et al., 2017). However, measuring sustainability performance is a complex process in light of many different expectations on economic, social and environmental responsibilities (Provasnek et al., 2017).

4.5.1 Sustainability indices

Despite the fact that the measuring the sustainability performance is a complex task, different indices were designed. An example of a sustainability measurement is the AIChE Sustainability index which consists of seven factors: strategic commitment to sustainability, sustainability innovation, environmental performance, safety performance, product stewardship, social responsibility and value-chain management (Cobb et al., 2009).

As this method is aimed at the performance of an enterprise, it is difficult to use the measurement scales directly for RI. However, some concepts can be used such as the effectiveness of R&D, the sustainability of products and the measurements on product stewardship (Cobb et al., 2009). Despite the fact that the sustainability index covers multiple aspects of sustainable innovation, the AIChE index does not indicate how to determine the sustainability of a product.

Other examples of a sustainability performance measurement tool are the Dow Jones Sustainability Index (DJSI) and the MSCI World ESG Index (Provasnek et al., 2017; Searcy & Elkhawas, 2012). Again, these metrics cover multiple aspects of sustainable innovation. Additionally, the sustainability indices allow companies to track their performance relative to peers and other industries (Searcy & Elkhawas, 2012). These indices also allow a typology of companies based on their sustainability performance which can support managers in their decision making. Furthermore, companies using those sustainability indices indicate that the indices provide feedback on their performance as it helps identifying areas for improvement (Searcy & Elkhawas, 2012).

However, these indices are not directly used to measure sustainability but they are often very crude proxies (Searcy & Elkhawas, 2012). Furthermore, these indices do not measure performance of products or do not give a clear indication on how to measure the performance of these products. Another limitation of this method is that the data required to determine the sustainability performance of companies is very limited (Provasnek et al., 2017). Finally, these indices and ratings can be prone to biases as these indices are aimed at industry leaders and do not take into account smaller sized companies and companies from emerging countries (Windolph, 2011).

4.5.2 Sustainability balanced scorecard

The BSC is known to be a popular method for measuring a company's overall business performance. Therefore, this method was used to capture the performance of sustainability as the Sustainability Balanced Scorecard (SBSC) is able to combine performance measurement with performance management in the three dimensions of sustainability (Figge et al., 2002; Schaltegger & Wagner, 2006). In order to develop a SBSC, six different steps have to be carried out in which the four different

perspectives of the normal BSC are taken into account and linked to a non-market sustainability perspective (Schaltegger & Wagner, 2006).

An important step in developing a SBSC is the definition of key performance indicators and the development of the measurement methods. The metrics designed in this step will be used to determine the sustainability performance (Schaltegger & Wagner, 2006). Furthermore, these metrics can be directly linked to one of the four perspectives of the BSC and thus overall business performance. Therefore, the SBSC is more a method in order to design sustainability performance metrics rather than a tool to assess the performance of a product directly. For example, for each specific RI, a SBSC have to be set up in order to determine its sustainable performance.

However, different accounting and reporting metrics have already been designed in SBSCs which can be used for the performance measurement of sustainability. For example, the energy usage during the production of a product, the amount of waste produced during the production of the product but also the % of the product that is recyclable and the amount of emission that is freed during the production of the product (Schaltegger & Burritt, 2000). These metrics however, are difficult to apply to the healthcare industry and focus more on the internal sustainability performance rather than the environmental performance of the product itself.

Economical sustainability performance metrics are also designed by use of the SBSC. Examples of metrics that address economical sustainability performance are the amount of jobs that for example a company creates in local areas that supports local economies (Epstein & Roy, 2003; Keeble, Topiol, & Berkeley, 2003). Another example is the amount of business opportunities that are created for local communities in order to support these local communities. Therefore, these metrics assessing the economical sustainability performance are aimed at both internal economical sustainability and external economical sustainability.

Next, social sustainability performance can be measured by taking into both internal and external metrics. For example, the work conditions can be measured of employees working on the development of the product. Furthermore, the safety of these employees can be measured and thus human rights can be taken into account (Keeble et al., 2003). Next, the amount of stakeholders that are engaged during the development of the project can be taken into account. External sustainability is taken into account by metrics that assess the improvement of local health or the protection of local communities (Keeble et al., 2003).

The SBSC is thus a useful method as it provides causal linkages between sustainability performance and overall business performance. In addition, the SBSC is a strong tool to support sustainability measurement and management as it helps to overcome shortcomings of other sustainability management systems (Figge et al., 2002). The SBSC can also be linked with sustainability accounting and reporting which are known methods to record, analyse and report sustainability impacts (Schaltegger & Wagner, 2006).

However, the SBSC is used to not only assess the sustainability performance but also overall business performance (Schaltegger & Wagner, 2006). Furthermore, the SBSC is used to come up with specific sustainability performance metrics that differ for each case and therefore, the SBSC is more a performance method than a tool with already defined metrics on how to assess sustainability performance (Schaltegger & Wagner, 2006). However, this could be an advantage as well as metrics could be designed that are specific to the healthcare sector such as patient and staff safety. Finally,

the metrics do not focus on the performance of a single product and their sustainability impact but on the sustainability of the production process of the product.

4.5.3 Sustainability implications

Measuring sustainability outcomes is thus a difficult process due to the fact that there is a complex interrelationship between the indicators and an absence of general agreement on the definition of sustainability. In order to overcome these difficulties, Shan & Khan (2016) took another approach in order to determine the implications that RI could have for the promotion of sustainability. This method consists of nine indicators which are grouped in three sets of three metrics that assess the three aspects of sustainability: environmental, economic and social value (Shan & Khan, 2016).

These metrics are based on the Sustainable Development Goals (SDGs) of the United Nations and they are directly linked to measure the sustainability of RIs (Levänen et al., 2015). Therefore, these metrics lack universal application as they are specifically designed for RIs. Table 4-4 displays the nine metrics that Shan & Khan (2016) designed to capture the sustainability implications of RIs.

Table 4-4 Sustainability indicators. From *Implications of reverse innovation for socio-economic sustainability: A case study of Philips China* by Shan & Khan (2016, p.5).

Ecological sustainability indicators	Are these RIs improving the environment users live in, for example, by pollution prevention or pathogen removal/health?
	Are these RI products material-efficient by being recyclable/reusable?
	Do these RIs cause potential environmental hazards such as noise, waste, emissions etc.?
Economical sustainability indicators	Do these RIs help in making health systems more cost-effective?
	Do these RIs carry a high cost-to-benefit (with regard to health) ratio for the users?
	Do these RIs provide meaningful solutions to their users at affordable prices?
Social sustainability indicators	Do these RIs improve the basic living conditions in terms of air, water, food, or shelter?
	Do these RIs improve awareness about healthy lifestyle and customs?
	Do these RIs ensuring better health and well-being for the marginalized people of the society?

This method by Shan & Khan does not require an intensive analysis to measure the sustainability implications and performance due to the fact that the indicators are easy to use. Furthermore, the method helps identifying the performance of all three aspects of sustainability and it is already adjusted to measure the performance of RIs. Furthermore, the method of Shan & Khan (2016) is based on the SDGs which are a reference point for sustainable development and therefore, they can ensure environmental, social and economic development (Caiado, Filho, Quelhas, de Mattos Nascimento, & Ávila, 2018). Lastly, these metrics are aimed the health of the society and therefore, they are suitable to measure the performance of healthcare innovations.

However, during the assessment of sustainability, the method showed that it was unable to assess the total effects of the practices that are undertaken to support sustainability as the three aspects of sustainable development are usually intertwined and subject to trade-offs (Shan & Khan, 2016). Furthermore, the indicators used in this method by Shan & Khan (2016) are closed questions and therefore, sustainability is in this method, a case of existing or non-existing. This means that different

RI products can have positives answers on the same metrics but for example one product might be more recyclable than the other. However, this problem can be solved by changing the metrics from closed questions into open questions.

4.5.4 Comparison of sustainability performance metrics

In this section, three different metrics were presented to measure the sustainability performance of a company or product. First, sustainability indices provides a good comparison of the sustainability performance of different companies and industries. Furthermore, it helped companies to identify gaps in their sustainability performance. Identifying gaps in order to improve sustainability performance can also be done by using the SBSC. This method is based on the BSC of Kaplan & Norton (1992) and consists of six steps in order to determine sustainability performance and support managerial decisions.

However, both methods fall short in measuring the sustainability performance of a product as they are focused on company sustainability and the sustainability of the production process and the internal sustainability performance. Therefore, Shan & Khan (2016) designed nine indicators that measure the sustainability implications that RI products have. This method is thus more aimed at the external sustainability performance of RIs than the internal sustainability performance and is already altered for both healthcare and RI. Finally, table 4-5 displays the strengths and the weaknesses of the three methods.

Based on the strengths and the weaknesses of the mentioned methods and metrics, a combination of both the SBSC and the method by Shan & Khan (2016) will be useful to assess both the sustainability of the production process of an RI and the sustainability implications the RI product has. However, the indicators designed by Shan & Khan (2016) are closed questions and which makes the comparison of sustainability performance of different RIs difficult. Therefore, a couple of indicators have to be altered in order to allow the comparison of sustainability performance of RIs.

Key Findings

- Three different approaches can be used to measure the sustainability performance of a company or product: sustainability indices, the SBSC and the sustainability implications method.
- Measuring sustainability performance is a complex task as there is an absence of general agreement on the definition of sustainability.
- Sustainability indices and the SBSC focus on the internal sustainability performance of a company such as the sustainability of the production process or the safety of employees.
- The method by Shan & Khan (2016) is focused on the sustainability performance of RIs instead of the sustainability performance of a company.
- A combination of the SBSC and the sustainability implications method is useful in order to assess both the internal sustainability performance and the external sustainability performance.

Table 4-5 Strengths and weaknesses of sustainability performance metrics.

	Sustainability indices	**Sustainability Balanced Scorecard (SBSC)**	**Sustainability implications**
Foundation	Differs for each index. For example, the AIChE index is based on seven aspects of sustainability	The Balanced Scorecard (BSC)	Sustainable Development Goals (SDGs)
Examples	The AIChE index, the DJSI and the MSCI World ESG Index	The % of the product that is recyclable, the amount of jobs that is created, the amount of stakeholder engagement	Are these RI products material-efficient by being recyclable, Do these RIs help in making health systems more cost-effective?
Strengths	- Cover multiple aspects of sustainability - Allows good comparison of sustainability performance between companies and other industries - Allows identification of gaps in the sustainability performance - Companies can identify their typology and based on this typology, decisions can be made that suit their typology.	- Causal linkages between sustainability performance and overall business performance can be identified - It support managerial decision making regarding sustainability performance - Can be linked with sustainability reporting and accounting	- Are easy to use - The performance of the three sustainability aspects is identified - Based on SDGs which are a reference point for sustainable development - Can be used to measure the sustainability performance of a single product - Is already aimed at RIs
Weaknesses	- Are often very crude proxies - Do not give a clear indication on how to measure the performance of a single product - The required data to determine the sustainability performance is very limited - Can be prone to biases	- Is more aimed at overall business performance rather than sustainability performance - Is specific for each company and therefore comparison between companies is difficult - Less focus on the sustainability performance of a single product	- It does not assess the total effects of the practices that are undertaken to support sustainability - Are closed questions - Does not take into account, the sustainability of the production process of the RI product

4.6 Interpretation and summary

Due to changing business environments, sustaining competitive advantage became the main emphasize of the business ecology. This led to the development of performance measurement tools that were combined with management in later stages of the development of performance measurement. First, performance measurement was only aimed at financial aspects and therefore, non-financial aspects were not taken into account. Hereafter, performance measurement took into account non-financial aspects due to revolutionary development of the BSC. In the BSC, three different perspectives were taken into account next to the financial perspective: customer perspective, the internal business perspective and the innovation and learning perspective. The BSC is observed to be a foundation of performance measurement and management and is used to form different types of performance metrics. However, some researchers argued that the BSC does not take into account all stakeholders. Therefore, sustainability performance metrics were designed as those metrics take into account social and environmental perspectives.

The focus of this thesis was to design a performance measurement framework on three perspectives: the financial perspective, the product innovation perspective and the sustainability perspective. First, there are three different types of financial metrics with their own strengths and weaknesses: the accounting-based metrics, the value-based metrics and the market-based metrics. In order to capture both long-term and short-term planning and forward looking and backward looking approaches, the accounting-based metrics in combination with the market-based metrics are most suitable to measure financial performance of RIs.

Second, different product innovation metrics were identified. The process approach identifies seven different processes that are required for innovation and for each the performance can be measured using multiple indicators. As this method takes a lot of time and effort, the efficiency and efficacy approach was designed by Alegre et al. (2006) which is more easy to use and has an adequate convergent validity of the constructs. Other methods used to measure innovation performance are the innovation capability approach and R&D performance measurement. Both these methods and metrics are more aimed at overall company performance rather than assessing the performance of product innovation initiatives. Therefore, a combination of the process approach and the efficacy and efficiency approach is suitable to measure the product innovation performance of RI. However, the metrics of the efficacy and efficiency approach have to be altered in order to use the method for measuring the product innovation of the company itself rather than assessing their performance as a comparison to the other companies. In addition, the process approach takes a lot of time and effort and therefore, only the first two processes are taken into account which are concept generation and product development which are similar to the first phases taken into account for the identification of different types of RI.

Third, different methods for the assessment of sustainability performance are discussed. Where the sustainability index and the SBSC focus on internal sustainability performance, the sustainability implications method focuses on the external sustainability performance and what the impact of RI is. Therefore, a combination of both the SBSC and the sustainability implications method covers both aspects of sustainability performance. However, the indicators of the sustainability implications method require some changes as these are closed questions.

5 Performance measurement: interview analysis

Chapter overview

This chapter contains the analysis of the interviews that were conducted to identify the performance metrics that are used in current practices of RI.

Section 5.1 starts with a general introduction of the analysis. Section 5.2 discusses the findings on RI and performance measurement. Section 5.3 focusses on the findings regarding financial performance metrics. Section 5.4 focusses on the findings regarding product innovation performance. Section 5.5 will discuss the findings on sustainability performance and section 5.6 will discuss additional findings on performance measurement.

5.1 Introduction

As mentioned in Chapter 4, performance measurement is a developing concept and performance metrics are becoming more important due to the fact that sustaining a competitive advantage and creating value became the main emphasis of the business ecology. For example, GE uses performance metrics in their daily business practices to make decisions and measure their overall business performance:

> *"We have some series of metrics to measure our day-to-day business and we have a monthly calendar to review the performance level per level; for example I am reporting to the general manager from our business and I have to present how our business is going following all those metrics." (Interview with product manager GE, May 13, 2021)*

Furthermore, the metrics can be used as a guidance tool in pursuing innovations as companies design those metrics based on their strategic aim. For example Philips designed a quadruple aim that consists of four important pillars: financial outcomes, patient outcome, patient satisfaction and staff satisfaction. The chosen metrics are then being formed according to these four pillars and the metrics are very important to thus deal with it and stick with it. This method of designing metrics based on the goals of the companies is also observed within in GE as there is a separate team of LEAN coaches that work together with different business teams to design the metrics.

5.2 Performance measurement and RI

In relation to performance measurement, all four companies indicated that they do not have specific metrics for RI as the same metrics are used across the company. This is due to the fact that there are separate teams designing those metrics according to the strategy and the aim of the company. Furthermore, the companies do not differentiate whether they are developing product for developing markets or developed markets. However, there can be a difference in how aggressive the targets are set for entry-level innovations that are developed for developing markets:

> *"For example, we use the same measures for the premium segment and the entry-level segment and we are not trying to create a separate set of definitions for these entry-level segments. However, the targets can be set differently and more aggressive for entry-level innovations to have a ceiling point for pricing and costs." (Interview with global portfolio manager Philips, May 14, 2021)*

The interviewees from Roche and Siemens provided another reason to use the same metrics throughout the company as it was mentioned that using the same metrics around the organisation so that the numbers can be easily spread around the organisation. Therefore, using the same metrics across the company can aid in the communication of a global organisation in which different regions and nations with their own business models and organisational tools have to be taken into account. Another reason to use the same metrics across the organisation is that it allows a comparison of the performance of different businesses in different regions within the organisation. So for example, premium-segment product innovations that are produced in developed countries can be easily compared to entry-level product innovations or reverse product innovations that are developed in emerging countries. In addition, the interviewee from Roche mentioned that certain metrics are used across the organisation due to the fact that those metrics are used all over the world such as the gross profit and other financial numbers.

What is interesting to note here is thus that within Philips, they do not differentiate whether they are developing products for developing markets or developed markets. The interviewee of Philips mentioned that this means that an RI is more like a process flow then a process compromise so RIs are more like logical extensions of products that are created in developing market that are strategically fitting into developed markets. Therefore, MNCs that are producing RIs, first focus on developing products in emerging countries that have a primary market within the emerging country. Hereafter, the MNCs will look for the opportunity to sell those products in developed markets to specific segments.

5.2.1 The definition of RI

Therefore, it is observed that these companies are mainly interested in strong types of RI as they are developing products within emerging markets and for emerging markets at first. This was also confirmed by their definition of RI:

> *"My definition and my understanding is that we started our business from china, from India or from other developing countries. During that period, we saw potential markets in those developed countries where we can sell our product too. (Interview with global product manager GE, May 13, 2021)*

AND

> *"In the case of RI, people are looking for innovations that are conceptualized, developed, tested and commercialize in developing markets and for emerging markets." … "Later, we expanded the horizon to take it to the developed market." (Interview with global portfolio manager Philips, May 14, 2021)*

But why are these innovations then produced and developed in emerging countries and why are these products then transferred to developed countries?

5.2.2 Reasons for producing RI

First, both GE and Philips mentioned that to produce healthcare innovations you want to be close to your biggest market which is in this case the emerging market. This is helped by the fact that a lot of knowledge is available locally, and therefore you will able to customize your product accordingly. Second, both GE and Philips stated that producing innovations in those emerging countries and for emerging markets allows you to source your parts and supplies locally. Therefore, your supply chain becomes better and more efficient which allows the companies to cut down the cost and the price of the innovation:

> *"For example in our Wuxi site, 98% of our suppliers are within an one-hour driving distance and so our supplies are more reachable. Therefore, we can have lower cost and on the other hand, we can have better supply chain resilience." (Interview with global product manager GE, May 13, 2021)*

AND

> *"The second reason is that developing countries are places where we can localise a lot parts." … "If they are sourcing it locally, you can save a lot of import duties and hassle of supply chain and what not." (Interview with global portfolio manager Philips, May 14, 2021)*

Third, in developing countries they do not have very strict protocols and there developing new innovations can be done in a shorter period of time. The interviewee from Philips mentioned that products that were designed in developed countries have a longer cycle of realisation. For example, it takes three to four years to launch a product in a developed market where it takes 15-18 months to launch a product in an emerging market indicating a time reduction of 50%. However, it is important to note that decreasing this launch time by having less strict protocols could results in a decrease in product quality and sustainability. Therefore, sustainability metrics and quality metrics are added in the performance measurement framework in order to prevent a decrease in quality and sustainability.

The fourth reason that MNCs are innovating in emerging countries is based on their history with innovations that were developed in emerging countries as the innovations from those countries have displayed that they are mature and of good quality. Finally, MNCs are always looking to expand and in the case of Philips, this meant that they wanted to expand to small-sized hospitals. By pursuing RI and producing innovations in developing countries, Philips was able to expand their portfolio and business.

Producing innovations in developing countries and for developing markets can thus help MNCs to lower the cost and the price of the product and expand their business. Furthermore Philips mentioned that the perception of customers towards products from emerging markets is changing. Due to his changing perspective, the interviewee from Philips indicated that they do not differentiate between innovations for developing markets and innovations for developed markets. Additionally, the interviewees of GE, Philips and Siemens indicated that the ideation of products is not done within a single country. For example in the case of GE, the product managers will generate new product ideas and they will have internal discussions with different functions and commercial leaders from different regions to discuss this new product idea. This also implies that the MNCs do not differentiate between

innovations for developing markets and developed markets and therefore, the same performance metrics are used for both type of innovations.

But why will these product managers than decide to transfer their products to developed markets? This is mainly due to the fact that the perception of customers towards products from emerging markets is changing. Therefore, MNCs were able to sell their emerging market products in developed countries which results in the increase of examples of RIs. Besides the change in customer perception, MNCs found that there are similar demands in specific segments of the developed market and the developing markets. For example, the interviewee from GE mentioned that private clinics from for Germany were using ultrasound systems for basic scans and basic diagnostics. Therefore, those clinics do not need the premium-end product to do the very detailed diagnostics because when they cannot see any lesions for example, they can refer them to higher-end hospitals. As those clinics are very price sensitive, they need to take care of the ROI and lower-end products are sufficient to fulfil their demands. This is also underlined by the interviewee from Siemens:

> *"If you have something to offer that is still from a big brand, that does the job, that is not a bad product, that is safe for the patients, that is very efficient and productive and it comes with a very simplistic user interface. Than you can convince the customer to buy this product." (Interview with product manager Siemens, June 4, 2021)*

Another reason for the transfer of RI to developed countries is that the low-end products can be used as back-up products in hospitals. Furthermore, the success of the innovations that were developed in emerging countries and for emerging countries was increasingly growing and therefore, customers in developed countries could not ignore the success. Finally, the interviewee from Siemens indicated that frugal innovation can be a trigger or a seed of RI. As frugal innovation is known for its disruptive nature, new business opportunities, new markets and new customer needs can be created (Rao, 2013).

However, in the case of Roche, there is still a difference in market needs observed and therefore, transferring products from emerging countries to developing countries will be unlikely. For example, they are designing products for emerging countries that will not be transferred due to the fact that in the world of the developed countries, the need for these products is less as they face no difficulties in infrastructure. Furthermore, transferring those low-end products can cause the cannibalization of your upper portfolio meaning that there can be a loss of sales of your upper portfolio. Therefore, separating those markets is an easy method to avoid the cannibalization of high-end products.

5.2.3 RI and market metrics

According to the companies, RI is thus a two-sided strategy of developing products in and for emerging countries and transferring those products to developed countries. However, in order to sell these products in developed countries, companies need to make a detailed analysis of these markets and their demands. This detailed analysis will then result in a holistic understanding of each country's healthcare system and if there are customers that the company wants to target as the customers are not the same in every country. For example, there can be differences in clinical usage, affordability and healthcare challenges the customers face every day and therefore, customer segmentation is important.

This is also underlined by the interviewee of Philips as they differentiate three different segments. The premium segments which are interested in the products with all the available features. Second, the

performance segments are interested in products that are designed with limited features or a slightly different platform. Third, the entry-level segment consists of value products for entry-level diagnostic centres and hospitals.
By performing these market analysis, companies can position their product and determine where to sell their RI and for which customer. For example, GE found that their business in the United Kingdom was small because based on the market analysis, it was observed that due to the National Health Service (NHS), only high-end products were of interest for both private clinics and hospitals.

Finally, In order to support the analysis of the developed markets, different market metrics are used. For example, the growth of the market size will be measured and how this market size is growing. Furthermore, the interviewees from Roche and GE mentioned that they use metrics on market access and market penetration. Finally, they take into account their own market share and the growth of this market share within different regions.

5.3 Financial performance metrics

As mentioned in the introduction, the financial performance metrics are nowadays of importance for MNCs as it reflects their decision making and illustrates the well-being of the company (Saad & Zhengge, 2015). The importance of financial metrics was also underpinned by the interviewees as financial performance metrics were the first metrics that the interviewees mentioned. During the interviews with Roche and Siemens, the business and financial metrics were of main interest.

But which financial metrics or numbers are used to measure the performance of RIs and their current business practices? First, all four MNCs indicated that they measure the profitability by either measuring the gross margin and the profit margin or by measuring the operating profit and the gross profit. Another method to measure the profit is by taken into account the earnings before interest, tax, depreciation and amortization (EBITDA). In addition to the profitability, the MNCs measure their revenues and the growth of their revenues:

> *"We are currently using financial metrics such as the revenue and order and their growth rates." (Interview with product manager GE, May 13, 2021)*

AND

> *"The second measure is the amount of sales that is realised from the customers." (Interview with global portfolio manager Philips, May 14, 2021)*

Next to measuring the profitability and the revenue, the interviewee from Roche mentioned that other common financial metrics are used such as the net present value (NPV), the internal rate of return (IRR) or the payback period. Those metrics are used to support the decision making regarding what projects to undertake and what product a company should discard (Ross, 1995). Furthermore, Roche uses different market-based metrics to assess their financial performance with relation to their stocks such as the earnings per share. Finally, the interviewee from GE mentioned that they take into account the NPI-vitality which is the portion of revenue that comes from NPI. However, this metric can also be categorised within product innovation performance as it measures the financial performance of new products.

5.4 Product innovation performance

Second, product innovation performance was taken into account as this has a large impact on the competitive position of a firm and product innovation performance has a positive link with overall firm performance (Calantone et al., 1995; Löfsten, 2014). From the interviews, it can be observed that most of the MNCs take into account product innovation performance to a certain extent by measuring for example the failure rate of products within the first 180 days. By measuring this failure rate of NPI, the quality of those NPI can be determined which is related to the product innovation performance.

Other metrics that are taken into account are on cost effectiveness. In the case of GE, they are interested in how they are spending their money and therefore, they measure their cost effectiveness by for example measuring the variable cost that is spend on shipment and interests. This is also underlined by Philips as the interviewee indicated that cost optimization is one of the key factors in their design of innovations due to the fact that they are initially innovating for emerging countries.

Furthermore, the interviewee from Roche mentioned that they measure the amount of patents that is registered, the number of products that are launched and they also measure the ratio of sales and R&D investment. On the contrary, the interviewee from Siemens did not mention any performance metrics that are aimed at the product innovation performance. However, the market share evolution or growth can be considered to measure the product innovation efficacy (Alegre et al., 2006).

Next to those metrics that focus on the costs and the investment, Philips also measures the first-pass yield which focusses on the manufacturing part of product innovation. The first-pass yield measures how many innovations passes the manufacturing on the first go without updating or changing the process system. Finally, as mentioned in the financial performance paragraph, GE measures the NPI-vitality which reflects on what percentage of the revenue of the entire portfolio is produced by new released products. This metric therefore clearly demonstrates how the new product innovations are accepted by the market.

5.5 Sustainability performance

Third, sustainability is one of the drivers of innovation and therefore, sustainability performance is becoming more and more important (Cobb et al., 2009; Kennedy et al., 2017; Provasnek et al., 2017). This is also underpinned by the MNCs in which they mention that it is mandatory to take into account safety and environment. In case of GE, sustainability is therefore a baseline of metrics and each business should be above this baseline in order to keep their business ‘healthy’. Examples of these metrics are aimed at the usage of materials, water pollution, air pollution and safety issues within the manufacturing site.

In case of Philips, almost similar metrics are used to reduce the environmental pollution. For example, they measure how much of their packaging material and components of the devices can be recycled. Furthermore, they also use a strict policy on the kind of materials they use for their products as they try to avoid any hazardous materials. In addition, they use a metric that is aimed at the reduction of the weight of the device so that less fuel will be used when transported and thus a lower carbon footprint will be realized. Finally, there are metrics that aim at reducing the carbon footprint of employees and manufacturing sites.

Within Roche, the same metrics are used to reduce the carbon footprint and the use of hazardous materials. In addition, they also have guidelines and metrics that aim at the reduction of the carbon footprint by employees and manufacturing. Furthermore, at the website from Roche, other KPIs were found that are aimed at social and economic sustainability, for example the community support by area and the amount of grants and donations to healthcare and patient organisation (Roche, 2021). Furthermore, Roche, Philips, Siemens and GE are all in the DJSI indicating that their sustainability performance for the company is measured (Philips, 2020; Roche, 2021; Siemens, 2010).

However, those metrics are less aimed at product sustainability and more at company sustainability. Furthermore, the interviewee from Roche was the only one that mentioned both social and economic sustainability. This thus indicates that measuring sustainability performance remains a difficult task within performance measurement and management. This is also underlined by the interviewee of Siemens as they are still looking for the right metrics:

> *"I would love to see examples where product sustainability and innovation sustainability can help us to see our portfolio management on a much larger scale." (Interview with product manager Siemens, June 4, 2021)*

So despite the fact that measuring sustainability is a rather complex task, the interviewees indicated that the those metrics and innovations will become more important as dealing with our resources that are becoming limited on a global scale, is becoming more and more important.

5.6 Performance categories

In the introduction of this research, the scope was set on three categories of performance measurement. However, during the interviews other categories were mentioned that the interviewees considered to be of importance. First, different market metrics were mentioned during the interviews that were already discussed in section 5.2. Second, the interviewees mentioned different customer metrics that customer metrics are of importance as well:

> *"I would say that customer success is the most important." (Interview with global portfolio manager Philips, May 14, 2021)*

In addition, all interviewees mentioned those customer metrics indicating the importance of this category. The interviewees mentioned multiple metrics that are taken into account. An example of a customer metric that was mentioned multiple times is the net promoter score (NPS) which displays the loyalty of the customers. Furthermore, the customer satisfaction rate (both patient and staff), the on-time delivery date, the infant failure rate, the call rate and the complaint rate are other examples of customer metrics that are used by the MNCs.

Another category that was mentioned by the interviewees was the people category that measures the development of employees and personnel. Those metrics are not directly focused on the business but they are used to track the development, safety and the diversity within the companies. For example, those metrics are mainly on the human resources (HR) side and therefore they are not directly related to RI business and they are considered to be softer aspects of the organization.

Finally, the interviewee from Philips mentioned metrics that involve safety and security which was named as the control category. These metrics are aimed at cyber security, physical security, patient security but also safety for the employees. So how many incidents happen for each products and how quickly are those incidents solved. Therefore, these metrics cover the safety of employees and the company which are part of the sustainability performance of the company.

5.7 Interpretation and summary

Performance measurement is used in the day-to-day business environments and the metrics that are used are based on the aim and the goal of the MNC. Furthermore, the same metrics are used throughout the organization which means that there are no specific metrics for RI within the MNC. There are a couple of reasons to use the same metrics within the whole organization. First, the metrics are thus based on the aim and goal of the company which is the same throughout the organization. Second, some interviewees mentioned that the companies do not differentiate whether they are developing products for emerging or developed markets. Third, using the same metrics allows better communication throughout the organization and fourth, a comparison between different products and business units can be made.

Furthermore, these MNCs observe RI as a logical extension of a product that is developing within an emerging country and for an emerging market. Therefore RI is observed to be a two-step process of developing a product within an emerging country and transferring it back to developed countries. There are a number of reasons why these MNCs pursue RI in this way. First, developing products within emerging countries means that you are close to your target market which is continuously growing. Second, a lot of suppliers are located within emerging countries and therefore you can have a better supply chain resilience. Third, developing countries have less strict protocols and therefore, innovations can be done in shorter period of time. Fourth, companies are always looking to expand their business and emerging markets provide opportunities to do so. These products are thereafter transferred due to the fact that they show success. Furthermore, there are similar demands within specific segments of developed markets and the perception of customers towards products from emerging countries is changing. However, in order to find market opportunities within developed countries, detailed market analysis is required which is supported by different market metrics

Regarding financial performance metrics, the MNCs have different metrics such as different profitability margins and rates, the revenue and its growth and key accounting numbers such as the NPV, the IRR and the EBITDA. Regarding product innovation performance, the interviewees mentioned different metrics such as the cost effectiveness, the product failure rate, the first-pass yield but also the amount of patents and product innovations that are done each year. Next, different metrics were used to measure sustainability such as the recyclability of the products, the use of hazardous materials and metrics that are aimed to reduce the carbon footprint by employees. However, the interviewees did not mention any metrics that measure the social and economic sustainability performance. Finally, the interviewees did mention other categories of metrics that are important such as customer metrics, people metrics and safety and security metrics.

6 Comparative analysis

Chapter overview

This chapter contains the comparative analysis between literature and current practices and the comparative analysis between different MNCs.

Section 6.1 starts with a general introduction of the analysis. Section 6.2 focusses on the comparative analysis between literature and current practices. Section 6.3 focusses on the comparative analysis between the interviews. Section 6.4 focusses on the comparative analysis regarding RI strategy between literature and practices.

6.1 Introduction

In the previous two chapters, different performance measurement metrics were presented that are either mentioned in literature or that are used in current practices of product innovation development. Both literature and current practices identified that performance measurement and management are important in current practices of product innovation and business management as those metrics reflect the aim and the goal of the company. Therefore, these metrics are designed by strategic teams at the top of the organisation and these metrics are then used throughout the organization.

This is also acknowledged within the literature as performance measurement systems are important tools to control a MNCs (Mahlendorf, Rehring, Schäffer, & Wyszomirski, 2012). Furthermore, literature shows that these performance measurement systems are a great mechanism to effectively manage the relations between headquarters and subsidiaries (Busco, Giovannoni, & Scapens, 2008; Dossi & Patelli, 2010). Next, these performance measurement systems that consist of different metrics, translate the activities from subsidiaries in measureable outcomes. Therefore, these performance measurement systems provide a basis for decision-making within the company (Busco et al., 2008; Dossi & Patelli, 2010). This is also mentioned by the interviewees as using the same metrics across the organization allows comparison of different innovations within different regions and subsidiaries.

6.2 Comparing literature and current practices

From the literature, different metrics were identified on three different aspects: financial, product innovation and sustainability. In addition, strengths and weaknesses were identified for those identified metrics. In the interviews, these aspects were also discussed and therefore, the comparison between literature and current practice can be made.

6.2.1 Financial performance

First, financial performance metrics will be discussed. In the literature, three different metrics to measure financial performance were discussed: the accounting-based metrics, the value-based

metrics and the market-based metrics. Those methods all have their strengths and weaknesses and based on the literature review a combination of both accounting-based metrics and value-based metrics was proposed.

From the interviews, it was observed that the MNCs are interested in accounting-based metrics as they measure the profitability of their products by taken into account the gross-margin and profit-margin. In addition, the interviewees mentioned other accounting-based metrics such as the revenue and its growth, the EBITDA, the IRR and the NPV. These metrics are thus accounting-based metrics and they are used to reflect upon the decision making and support their decision making regarding innovation projects. In addition, different market-based metrics are used by Roche to assess their financial performance (Roche, 2021). Finally, the interviewees mentioned that those metrics are important as they clearly reflect the business, they are easy to spread across the company and easy in use:

> *"From a financial perspective, those are common languages that are used. These are understandable measures and everybody will understand those measures like for example, the discount rate, the NPV or the IRR. Therefore, it is easy to spread those numbers around the organisation" (Interview with international product manager Roche, May 18, 2021)*

The ease of use and the ability to reflect on the profitability of the firm are strengths that are identified within the literature (Masa'deh et al., 2015; Venanzi, 2012). However, it is important to reflect on the interviews. These interviewees are product managers and therefore, they use metrics that are only aimed at their innovation projects rather than the whole organization. Therefore, it could be that higher management uses value-based metrics or market-based metrics. This means that it is not possible to exclude these metrics based on interview data.

6.2.2 Product innovation performance

Second, product innovation performance is discussed. From literature, four different metrics were identified that were able to measure the product innovation performance: process approach, efficacy & efficiency, innovation capability and R&D. Those methods all have their strengths and weaknesses and based on the literature review a combination of the process approach and the efficacy and efficiency approach is able to capture product innovation performance.

Regarding product innovation performance, the interviewees mentioned different metrics such as cost effectiveness and cost optimization as these are key in developing products for emerging markets. In addition, NPI-vitality and the product failure rate within 180 days is measured to indicate whether these products are successful. However, the NPI-vitality can also be classified as a financial metric as it measures the percentage of sales that is generated by NPI. Furthermore, this metric can cause the promotion of small product developments (re-innovations) and therefore, business units are encouraged to replace older products with new ones just to reach their target (Cooper, 2013). This indicates that the use of NPI-vitality also has its weaknesses despite the fact that it is observed to be the key performance metric within many firms (Cooper, 2013).

Another metric that can be considered to be a product innovation performance metric is the growth of market share which is also mentioned within the product innovation measurement tool by Alegre et al. (2006). Finally, the interviewee from Roche mentioned that they are interested in the amount of patents that are successfully registered and the amount of innovations that are launched every year.

This interview data shows that the MNCs are not aligned on product innovation metrics and the interviewee from Siemens mentioned that he is not aware of performance metrics that are aimed at product innovation performance, products sustainability and innovation sustainability. The differences within the metrics that the companies mention and the fact that the interviewees are not aware of product innovation metrics indicates that the interviewees might not had the right knowledge on product innovation metrics. Therefore, providing the interviewees with information on what product innovation metrics are, could have been valuable as the interviewees could have been able to relate to these product innovation metrics. Finally, the metrics that are mentioned by the interviewees are not detailed and only a few examples are provided indicating that comparison between literature and current practices is difficult.

However, comparing literature and the few examples that are provided within current practices, they partially overlap as for example, cost effectiveness is both in the tool of Alegre et al. (2006) and Chiesa et al. (1996). Furthermore, the first-time pass yield that was mentioned in the interviewee by Philips is comparable with the time to market metrics that are mentioned in the tool of Chiesa et al. (1996). Next, both failure rate, amount of patents and innovations are also mentioned in the measurement tool of Chiesa et al. (1996).

Another important point to note is that within the tool from Chiesa et al. (1996), customer satisfaction is used to measure the concept generation performance. The interviewee from Philips indicated that customer metrics are important for their business in the healthcare as a higher customer satisfaction will directly lead to a better business performance. Therefore, customer metrics are considered to a stand-alone category within MNCs rather than a part of product innovation performance.

This is also underlined by the article of Chiesa et al. (2009). Companies that are aimed at new product development and thus have diagnostic objectives, should focus on financial metrics but also on customer metrics. This indicates that they observe customer metrics as a stand-alone category. Furthermore, customer metrics are a stand-alone perspective within the BSC that was designed by Kaplan & Norton (1992) and therefore, customer metrics should be mentioned apart from the product innovation performance metrics (section 6.2.4.)

Finally, the interviewee from Siemens indicated that frugal innovation can be observed as the ‘seed’ of RI. As frugal innovation often has a disruptive element, they are able to open new markets. This is also covered within the performance measurement tool of Alegre et al. (2006) with the following metric: “opening of new markets abroad”. This metric therefore applies well to RI within the healthcare sector as this metric is able to capture how many markets within developed countries are opened describing the success of an RI product.

Based on the knowledge from literature and current practices, a combination of the process approach and the efficacy and efficiency model should be able to capture the product innovation performance of RIs within the healthcare sector. However, the interviewees did not provide many different performance metrics for product innovation performance indicating that the interviewees might not have the right knowledge or are not aware of the product innovation performance used within the company. Therefore, interviews should have been performed with employees from the R&D departments as well as they could have provided us with more detailed examples of product innovation performance metrics.

6.2.3 Sustainability performance

Third, sustainability performance metrics will be discussed. In literature three different approaches were identified that measure the sustainability performance of either a company or a product: sustainability indices, the SBSC and the sustainability implications. These approaches and metrics all have their strengths and weaknesses and based on the literature a combination of the implications approach and the SBSC was observed to cover both internal and external sustainability.

Regarding sustainability performance the interviewees mentioned a few examples of metrics that are used within their MNC. These metrics are mainly aimed at the environmental aspect of sustainability for example the recyclability of the packaging material and the components used in the product. Furthermore, companies try to prevent the usage of hazardous materials as much as possible, decrease the weight of their products and measure the carbon footprint of their employees and reduce this carbon footprint. However, the interviewee from Roche was the only one that mentioned sustainability metrics that were aimed at social and economic sustainability. Finally, the interviewee from Siemens indicated that measuring sustainability remains a complex task and he is not aware of how sustainability within the company and for products is done.

The few examples of sustainability performance metrics mentioned within the interviews could indicate that measuring sustainability is still a complex task as the definition of sustainability is still complex as well (Ben-Eli, 2018). However, it could be that the interviewees did not have the exact knowledge on sustainability metrics and that interviews with employees within R&D or sustainability teams may be required to find out the different sustainability performance metrics.

Despite the fact that the interviewees mentioned only a few examples of sustainability performance metrics, they do partially overlap with the literature. From the SBSC, different metrics that take into account recyclability and pollution were mentioned which are identical to the metrics that the interviewees identified (Schaltegger & Burritt, 2000). Furthermore, metrics that take into account the carbon footprint and energy intensity are also used within Roche.

Another interesting point here is that the interviewee from Philips mentioned their control category in which they measure the safety and security of employees and patients is measured. According to Keeble et al. (2003), these metrics are part of sustainability in which work conditions play an important role. Next, job creation and the support of local economies can also be measured in order to determine sustainability performance (Epstein & Roy, 2003). These metrics are also taken into account by different KPIs from Roche. For example, Roche is interested in the amount of donations and grants to healthcare and patient organisation and the amount of community support by area (Roche, 2021). Finally, all four MNCs are in the DJSI in order to determine the overall sustainability performance of the company in comparison to other MNCs.

However, these metrics are mainly aimed at the sustainability performance of the company rather than the sustainability performance of a single product or RI. Therefore, the tool from Shan and Khan (2016) can be added in order to measure both internal and external sustainability performance. Besides, the control and security metrics from Philips can be categorised within the sustainability performance as Keeble et al. (2003) mentioned that metrics on working conditions are part of social sustainability metrics.

6.2.4 Customer satisfaction performance

As mentioned in section 6.2.3, the interviewees mentioned different customer metrics that are important for their organisation and in measuring the performance of their innovations. Different examples of customer metrics were presented such as customer satisfaction (both patient and staff), the complaint rate and the NPS. Furthermore, in the case of Philips, they put those customer metrics on the first place as in their view higher customer satisfaction will directly lead to a better business performance and financial performance:

> *"From the perspective of Philips, we feel that if we have great performance on customer success, the commercial success will be there. For example, a happy customer will always provide more business and at the same, we will have a more lasting relationship" (Interview with global portfolio manager Philips, May 14, 2021)*

The importance of customer metrics is underpinned by the literature as customer metrics are key for companies that are interested in sustaining a competitive advantage by producing new products (Chiesa et al., 2009). Furthermore, literature also shows that satisfying customer needs within the healthcare becomes more and more relevant as organizations change their standard operational procedures due to the fact that the competition and demand in this industry is growing (Gonzalez, 2019).

From the interviews, it was observed that all interviewees mentioned customer metrics as a separate category and explained the importance of customer metrics within the healthcare industry. Furthermore, the interviewee from Philips mentioned that from his perspective, customer metrics are the most important metrics to measure the company or product performance. In addition, literature underlines the importance of customer satisfaction and metrics within the healthcare industry and new product development. Therefore, customer metrics can be taken into account for the design of the performance measurement framework.

In the interview, the NPS was a customer metric that was mentioned multiple times. The NPS refers to a single question which is: "how likely is it that you would recommend our company to a friend or colleague?" (Krol, de Boer, Delnoij, & Rademakers, 2015). The consumers can then give an answer from 0 ('not at all likely') to 10 ('extremely likely'). If the answer is between 0 and 6, the consumers is dissatisfied with the service or product. If the answer is 7 or 8, the consumer is satisfied with the product and if the answer is 9 or 10, the consumer is very satisfied and will likely recommend the product or service to other customers (Krol et al., 2015).

This metric can therefore be used by different hospitals and private clinics to measure the customer satisfaction. In addition, these healthcare MNCs use this metric to determine the satisfaction of the staff that works with their healthcare innovations. However, the NPS reflects the customer satisfaction in the healthcare to a limited extent (Krol et al., 2015). Therefore, customer surveys can be added which were mentioned by the interviewees as well. In addition, small customer metrics such as the complaint rate, the on-time delivery date and the call rate. These rates indicate how many complaints the company receives regarding a product, if the company is able to deliver their product on-time and how many times a customer calls for feedback or support.

Key Findings

- MNCs are mainly interested in accounting-based metrics for their innovations. However, value-based metrics cannot be excluded as they might be used by higher management.
- A couple of product innovation metrics overlap that were mentioned by the interviewees overlap with the product innovation metrics of Chiesa et al. (1996) and Alegre et al. (2006).
- The interviewees are mainly using environmental performance metrics that were mentioned by Schaltegger & Burritt (2000). However, there is less focus on social and economic sustainability and therefore, the measurement tool of Shan and Khan (2016) is a good addition.
- The interviewees mentioned the importance of customer satisfaction metrics which is underlined by Chiesa et al. (2009) as customer metrics are key for companies that are interested in producing NPIs.

6.3 Comparing current practices

In the previous section, the metrics that were identified from literature were compared with the metrics that were mentioned by the interviewees. However, within the interviews there are also differences and similarities and therefore, a second comparative analysis between the different MNCs is made.

6.3.1 Financial performance

Regarding financial performance, the MNCs mentioned multiple examples of metrics that are used in their day-to-day business. Table 6-1 displays the metrics that each MNC uses to measure their financial performance.

Table 6-1 Financial performance metrics of MNCs

	GE	Philips	Roche	Siemens
Revenue	X	X	X	
Revenue growth	X			
Sales margin/gross margin	X	X	X	X
Contribution margin	X			X
EBITDA		X		
NPV			X	
IRR			X	
Cost earnings per share			X	

It is observed that all companies are interested in the sales margin/gross margin and most of the MNCs are measuring the revenue of their products in order to determine its financial performance. In addition, the interviewee from Philips mentioned that they are mainly focused on their revenue indicating the importance of this metric. Therefore, these two metrics can be considered to be relevant in measuring financial performance within current practices. Furthermore, it is observed that Roche is the only MNC that mentioned the NPV and the IRR in project decision making. It could be that either these other MNCs do not use these metrics or that they did not thought of those metrics during the

interview. Therefore, in order to have a better comparison between MNCs, a list of financial metrics could have been made and the interviewees would have been able to select which financial metrics they use.

The same holds for the EBITDA metric that was mentioned by the interviewee from Philips. This metric is used a lot within the capital-intensive industry on a voluntary basis as it is not part of standard procedures to report financial outcomes (Bouwens, De Kok, & Verriest, 2018). Therefore, it could be that these other MNCs are not using this metric or did not mention it within the interview. However, the comparison is difficult in between companies due to the fact that the interviewees could have forgotten on different performance metrics. Therefore, it is difficult to recommend one financial performance metric over the other. However, given both the emphasize from the interviewee from Philips on revenue and the fact that both the revenue and the sales margin are used within at least three MNCs, it can be observed that revenue and sales margin are a common reference point within the financial performance measurement.

6.3.2 Product innovation performance

For product innovation performance, different metrics were mentioned in the interviews. The interviewee from Siemens could not think of any product innovation performance metrics. However, he did mention a couple of examples which can be classified as product innovation performance metrics (table 6-2).

Table 6-2 Product innovation performance metrics of MNCs

	GE	Philips	Roche	Siemens
Failure rate within 180 days	X			
Cost effectiveness/control/ optimization	X	X	X	
NPI-Vitality	X			
First-pass yield		X		
Market share growth	X			X
Ratio of sales and R&D investment			X	
Number of patents			X	
Number of innovations			X	

From table 6-2, it can be observed that cost effectiveness, cost control or cost optimization is an important metric to measure product innovation performance. Furthermore, the interviewee from Philips mentioned that this cost optimization is one of the key factors in the design of innovations. This is due to the fact that these RIs are initially aimed at emerging countries and very price sensitive customers. Therefore, taking into account cost optimization can be a relevant metric for producing RIs within the healthcare industry. However, it is difficult to compare the other metrics as there are only a few examples of product innovation performance metrics. This could mean that the interviewees were not aware of a lot of product innovation performance metrics and that interviews with employees from other functions are required. In addition, as with financial performance metrics, the different methods or metrics could have been presented to the interviewees and the interviewees could then select which metrics they use or are familiar with in their MNC. Finally, based on the emphasis from the interviewee from Philips and the fact that three MNCs mentioned cost optimization, this metric can be used as a common reference point within product innovation performance.

6.3.3 Sustainability performance

Next, different sustainability performance metrics were mentioned within the interviews. In the case of Siemens, the interviewee did not mention any sustainability performance metrics. However, they are in the DJSI which is their only sustainability performance metric (table 6-3).

Table 6-3 Sustainability performance metrics of MNCs

	GE	Philips	Roche	Siemens
Water and air pollution reduction	X		X	
Reduced use of hazardous material	X	X	X	
Recyclable product parts		X		
Weight minimization		X		
Recyclable packaging		X		
Energy consumption			X	
Carbon footprint per employee		X	X	
DJSI	X	X	X	X
Safety of employees		X		
Amount of community support			X	

From table 6-3, it is observed that the both Philips and Roche mentioned a lot of different examples of sustainability metrics. Furthermore, it is observed that the reduction of the use of hazardous materials is an important metric to take into account for product development which was underlined by the interviewee from GE as he mentioned that for the device business, it is mainly about the materials that are used for the production of a healthcare device. In addition, all four MNCs are in the DJSI indicating the importance of being part of this sustainability metric. However, the comparison of these metrics is rather difficult as the interviewees might have missed out on different aspects of sustainability such as the safety of employees as this is important within every MNC. Therefore, sustainability and its different aspects had to be explained before the interview in order to let the interviewees relate to one of the three aspects and mention different performance metrics. By providing the interviewees with information beforehand, the interviewees would have been able to provide more knowledge on social and economic sustainability performances.

Regarding product sustainability metrics, Philips mentioned the most different sustainability metrics which are aimed at the environmental aspect of sustainability performance. For example, the recyclability of both product parts and packaging and the minimization of the weight in order to reduce the carbon footprint of a product. Philips was the only company to mention these sustainability performance metrics which could indicate that they value product sustainability more than the other companies. However, it could be that the interviewees of the other MNCs did not had the knowledge on the specific product sustainability metrics and therefore, interviews with different employees from the MNCs would have been better. Finally, it is observed that metrics regarding environmental sustainability are a common reference point within sustainability performance measurement.

6.3.4 Customer satisfaction performance

Finally, customer satisfaction performance is discussed as all interviewees provided examples of those type of metrics. Table 6-4 shows the different metrics the MNCs use in order to measure customer satisfaction.

Table 6-4 Customer satisfaction performance metrics of MNCs

	GE	Philips	Roche	Siemens
On-time delivery date	X			
Infant failure rate	X			
Customer survey			X	X
NPS		X		X
Call rate		X		
Complaint rate			X	

It is observed that the customer metrics are different in between all MNCs except the NPS and the customer survey. Furthermore, there are different rates such as the call rate and the complaint rate which are almost similar. For example, the call rate is how many times the MNC receives a call from customers regarding the feedback and support and the complaint rate are the amount of complaints the MNC receive relative to the number of installations of a specific device. As there are less similarities in between the MNCs, it is difficult to rank one metric over the other. Furthermore, employees within customer relationship management departments have more knowledge regarding customer satisfaction performance.

Key Findings

- MNCs are mainly interested in the revenues of their products and the sales/gross margin of their product. However, comparison remains difficult as interviewees could have overlooked different metrics.
- Cost effectiveness is one of the key metrics in measuring product innovation performance as RIs are aimed very price sensitive customers.
- All four MNCs are in the DJSI indicating the importance of measuring the sustainability performance of the MNC by using this index. However, the interviewees mentioned less performance metrics regarding social and economic sustainability performance of products.
- NPS and customer surveys are used within two MNCs to measure customer satisfaction. However, comparison between companies remains difficult as the interviewees might not had the right knowledge.

6.4 Comparison RI strategy

In Chapter 2 of this thesis, different definitions of RI were proposed and RI was observed to be a separate strategy and Rosca et al. (2017) even proposed a business model for frugal innovation and in some extent RI. However, the interviewees indicated that RI is more a process flow then a process compromise. This means that those RIs are more like a logical extension of products that are created in and for emerging countries that logically transfer and fit into developed markets. Furthermore, the interviewee of Siemens underlined this as he mentioned that RI is not a term that is often used within the organisation in which he is familiar with.

As mentioned, RI is thus more a logical extension than a separate strategy and this is due to the fact that the MNCs observe RI as a two-step process flow. The first step is designing a product innovation in and for emerging countries and the second step is transferring this innovation back to developed markets if there is an opportunity to sell these products.

The interviewees provided several reasons for both producing innovations in and for emerging countries such as a better supply chain resilience, more local knowledge of the market, shorter development time and market expansion. Due to the fact that there are several reasons for producing products in and for emerging countries, MNCs are more and more interested to move different offices to these emerging countries.

As producing and developing products in developing and emerging countries has several advantages, MNCs will have less interest in developing products within developed countries for emerging countries. This could explain the fact why there are less examples of weak RIs which makes comparison between weak and strong RI more difficult. Furthermore, this could also indicate that MNCs are not interested in pursuing weak types of RI or do not distinguish different types of RI that were proposed by Von Zedtwitz et al. (2015). This is partially underlined by the interviewee from GE as for example product ideation is a process that does not take place in only country:

> *"Usually, when we have new ideas for a new product, it is up to us to generate those new ideas and of course we have internal discussions with different functions and even the commercial leaders from different regions." (Interview with product manager GE, May 13, 2021)*

AND

> *"When we have new products to define, an when we are generating those ideas. We need to have discussions with almost all regions to make sure that this idea is applicable to all regions" (Interview with global portfolio manager Philips, May 14, 2021).*

The interviews show that the MNCs are not using the typology of Von Zedtwitz et al. (2015) to classify the different types of RI as they observe RI as two-step process and some phases of the innovation process are scattered across the world. However, it might be that these interviewees did not had the exact knowledge on the RI typology within the company and therefore, the typology of Von Zedtwitz et al. (2015) can still be useful to take into account in order to identify different types of RI. Furthermore, this typology is still relatively new and therefore, it could be that the interviewees were not aware of the typology.

As RI is a growing concept, there will be more examples of RI in the future and therefore, the typology of Von Zedtwitz et al. (2015) will be more useful. However, considering the reasons to produce and develop RIs within emerging countries, a lot of examples will be strong RIs. Furthermore, RI is observed to be a logical extension of product for emerging countries rather than a separate strategy. But why do these MNCs transfer those RIs?

In chapter 5, a few reasons for transferring those RIs were already mentioned such as the similar demands that some segments of developed markets have in comparison to the emerging markets. This was also mentioned in the article by Govindarajan & Ramamurti (2011). Furthermore, there is a change of perception from customers in developed countries and these products from emerging countries can create new markets. The creation of new markets by these products of emerging countries was also mentioned as a possible reason in the article of Govindarajan and Ramamurti (2011).

Therefore, the possible reasons that were mentioned by Govindarajan and Ramamurti (2011) are observed within current practices of MNCs. However, the interviewee from Roche mentioned that a difference in demands can also be a barrier that prevents an innovation to transfer from an emerging country to a developed country. In addition, only two interviewees provided the knowledge on why those innovations are transferred to developed countries and therefore, further research is required.

6.5 Interpretation and summary

By comparing literature and current practices, it was observed that MNCs are mainly focused on accounting-based metrics that were mentioned in the literature such as revenue and gross margin. However, value-based metrics are a good addition to these accounting-based metrics according to the literature. Regarding product innovation performance, companies are mainly interested in cost effectiveness which is part of the measurement tool of Alegre et al. (2006) and Chiesa et al. (1996). In addition, the interviewees mentioned other metrics that are focused on customer satisfaction which is considered to be a stand-alone category. However, the interviewees did not mention a lot of examples of product innovation performance which could be due to the fact that the interviewees did not had the right knowledge on product innovation performance. Thereafter, sustainability performance was discussed and an interesting difference between literature and current practices is the emphasis towards the DJSI. Based on literature this metrics was thought to be not useful. However, all four MNCs are registered within the DJSI to measure their company sustainability performance. Next, the interviewees mentioned different metrics that are aimed at environmental product sustainability which overlap with the method from Schaltegger & Burritt (2000). However, there is less focus on social and economic product sustainability and therefore, the method from Shan and Khan (2016) is a good addition to measure sustainability performance. Finally, customer satisfaction is added a stand-alone category as both the interviewees and literature indicate the importance of customer satisfaction in both healthcare and product innovation.

The comparative analysis between companies is rather difficult as there are only a couple of examples of performance metrics. However, regarding financial performance, both revenue and gross margin were mentioned the most indicating their importance within MNCs. Regarding product innovation performance, cost effectiveness is observed to be an important metric as three of the MNCs are using. Next, for sustainability performance, the MNCs are all in the DJSI indicating that this is an important metric for company sustainability. For product sustainability performance, three of the MNCs are measuring their reduction of hazardous materials that are used within the product. Therefore, the environmental metrics are observed to be a common reference point within measuring sustainability performance. The final category is the customer satisfaction performance in which customer surveys and the NPS are of importance However, the interviewees did not provide many examples and therefore, ranking one metric over the other is rather difficult.

Finally, the difference between current practices and literature is discussed regarding RI as a strategy and typology. Within current practices, RI is observed to be a logical extension of products that are developed in and for emerging markets rather than a clear strategy. Furthermore, they observe RI as a two-step flow that consists of developing a product in and for emerging countries and transferring it back to developed countries. Pursuing RI by using this two-step flow has several advantages which could explain the fact that there are less examples of weak RI. Furthermore, phases from the typology of Von Zedtwitz et al. (2015) such as the ideation of products, take place in a lot of different regions rather than in one region. However, the typology of Von Zedtwitz et al. (2015) is relatively new what

could indicate the interviewees are not aware of it yet and that there are less examples of different types of RI. Finally, the reasons for transferring RI are similar to the possible reasons that were stated by Govindarajan and Ramamurti (2011). However, further research is required to confirm the reasons to transfer these innovations to developed countries.

7 Conclusion and recommendations

Chapter overview

This chapter contains the answers to the sub-questions and the main research question. Furthermore, the limitation of this study and recommendations for further research are discussed.

Section 7.1 starts with the answers to the sub-questions. Section 7.2 focusses on the answer to the main research question and provides the performance measurement framework. Section 7.3 discusses the key findings of this research and section 7.4 shows the contribution of this thesis. Section 7.5 will discuss the limitations of this study and some recommendations for further study. Finally, section 7.6 discusses the relevance of this study with relation to the completion of a MSc. thesis.

7.1 Answers to sub-questions

The main objective of this thesis was to design a performance measurement framework for RI in the healthcare sector. In order to do so, the main metrics in literature and current practices had to be identified. Therefore, the first sub-questions was:

Sub-question 1:	Considering the three types of performance categories, what are the performance metrics identified in existing literature?

In order to answer this question, a literature analysis was performed. Based on the literature, three different types of financial performance metrics were identified: accounting-based metrics, value-based metrics and market-based metrics (Masa'deh et al., 2015; Venanzi, 2012). These three different types all have their strengths and weaknesses (table 4.1). For example, the accounting-based metrics can support decision making and provides information on the profitability of the firm. However, those metrics are susceptible to managerial manipulation (Masa'deh et al., 2015; Venanzi, 2012). The value-based metrics can be used for long-term planning but they are more complex in use (Venanzi, 2012). Finally, the market-based metrics are not limited to a single aspect of the MNC but are misaligned by comparing present values to historical values (Gentry & Shen, 2010; Mcguire et al., 1988). Based on these strengths and weaknesses, a combination of both accounting-based and value-based metrics is able to capture the financial performance of both product and company.

Regarding product innovation performance, four different types of metrics were identified: process-approach, efficacy & efficiency, innovation capability and R&D metrics (Alegre et al., 2006; Birchall et al., 2011; Chiesa et al., 1996; Saunila & Ukko, 2012). Again, those metrics all have their strengths and weaknesses which are presented in table 4.3. Based on the strength and the weaknesses of these metrics, the process approach and the efficacy & efficiency method is able to measure the product innovation performance. However, for the process approach only the two processes are taken into account to measure product innovation performance as they are identical to the phases that Von Zedtwitz et al. (2015) used in their typology.

Finally, sustainability performance metrics where discussed and three different methods were identified: the DJSI, the SBSC and the sustainability implications (Cobb et al., 2009; Schaltegger & Wagner, 2006; Shan & Khan, 2016). Based on the strengths and the weaknesses of those methods, a combination of both the SBSC and the sustainability implications model was proposed as a suitable tool to measure both internal and external sustainability.

Sub-question 2: Considering the three types of performance categories, what are the performance metrics used in current practices of RI?

In order to answer this question, four interviews with product managers from multiple MNCs in the healthcare sector were performed. Regarding financial performance, the interviewees provided several metrics that are used within their company such as the revenue and its growth, the sales margin, the EBITDA, the NPV and the IRR.

Regarding product innovation performance, the interviewees also mentioned multiple examples such as the growth of their market share, the NPI-vitality and the first-pass yield for manufacturing. Furthermore, the companies are interested in cost effectiveness which they mentioned is important if your customers are price-sensitive.

Next, the interviewees mentioned some sustainability performance metrics. The interviewees mentioned the DJSI and other environmental performance metrics such as the reduction of hazardous materials and the recyclability of the product. However, they did not mention any exact metrics on social and economic sustainability indicating the complexity of measuring sustainability performance. This was also underlined by the interviewee of Siemens that mentioned that he was not aware of sustainability performance metrics.

In addition, the interviewees indicated that measuring customer satisfaction is an important metric for the healthcare industry and the interviewee from Philips even indicated that in his perspective, customer metrics are the most important in their business due to the fact that he believes that financial performance will come if your customer satisfaction is high. Furthermore, all interviewees mentioned different examples of customer satisfaction metrics indicating the importance of those metrics within the healthcare sector. Customer satisfaction can be measured by the NPS, customer surveys but also the complaint rate and the call rate.

Finally, the interviewees indicated that there are no separate metrics for RI projects as they use the same metrics throughout the company as the MNCs do not differentiate between developing product for emerging markets or developed markets. Furthermore, using the same metrics throughout the organisation provides better communication within these global organisations allowing numbers and information to be easily spread. Another reason is that using the same metrics allows comparison in between different products. Furthermore, some metrics are used as they are used all over the world and are becoming standard within different disciplines. Despite the fact that the MNCs do not differentiate between innovating for emerging markets and developed markets, the metrics and targets can be stricter for products that are aimed at emerging markets. For example, these entry-level innovations for developed markets can have more aggressive targets regarding pricing and costs.

Sub-question 3: Based on and comparing the performance metrics gathered from the literature and those from current practice, how should an RI performance framework be developed?

Based on the current practices within financial performance measurement, accounting-based metrics are used the most in comparison to value-based metrics and market-based metrics. However, based on literature the value-based metrics are observed to be a good addition towards the accounting-based metrics as they can be used in long-term planning and provides a clear indication of stock return (Venanzi, 2012). In addition, it is not susceptible to managerial manipulation and therefore, it can be a good addition to the accounting-based metrics that are susceptible to managerial manipulation (Venanzi, 2012).

Regarding product innovation performance, the interviewees did not provide many examples of metrics. However, it could be observed that cost effectiveness is an important metrics within current practices and therefore, it should be included within the performance measurement framework. This metric is also part of both methods from Chiesa et al. (1996) and Alegre et al. (2006) which is the best combination to measure product innovation performance based on the literature analysis. Furthermore, market share growth that was mentioned in the interviews can be an important metric that covers the efficacy of these product innovations (Alegre et al., 2006). So despite the fact that the interviewees did not provide many examples of product innovation performance, the metrics that were mentioned are aligned with the methods of Chiesa et al. (1996) and Alegre et al. (2006) indicating that these methods measure the product innovation performance.

Regarding the sustainability performance of the MNCs and the RIs, this is a rather complex task within the MNCs. Based on literature, the SBSC and the implications model of Shan and Khan (2016) are the best combination of performance metrics. However, interview data shows that all companies make use of the DJSI and thus sustainability indices to measure company sustainability performance. Therefore, a combination of the three methods will be used within the performance measurement framework. This means that the DJSI can be used to assess company sustainability performance, the SBSC can be used to measure the internal sustainability performance and the sustainability implications performance metrics can be used to measure the sustainability performance of the RI product itself.

Finally, customer satisfaction metrics will be added to the performance measurement framework as all interviewees indicated that they are used within their MNC. Furthermore, customer satisfaction metrics are important to measure the day-to-day business of MNCs that are interested in new product development (Chiesa et al., 2009). It is noted that customer satisfaction performance measurement is becoming more and more important within the healthcare industry and therefore, the addition of customer satisfaction metrics such as the NPS and customer surveys will be useful in measuring the performance of RIs within the healthcare sector.

7.2 Answer to main research question

Main Research Question

What metrics are needed in a performance measurement framework for RI in the healthcare sector?

By integrating the findings of the sub-questions, the main research question can be answered and in table 7-1 the performance measurement framework is presented. Due to the addition of the customer metrics, four different categories are presented: financial performance, product innovation performance, sustainability performance and customer satisfaction performance. For financial performance, accounting-based metrics and value-based metrics can be used to assess both product and company performance. Besides, companies indicated the usefulness of accounting-based metrics in their day-to-day business.

Regarding product innovation performance, the metrics from Chiesa et al. (1996) and Alegre et al. (2006) can be used to measure its performance as it captures both the internal performance of product innovation and the efficacy of these innovation products. Besides, the metrics of the first two innovation processes in the audit tool of Chiesa et al. (1996) are similar to the first processes of the typology of Von Zedtwitz et al. (2015).

Based on literature, the SBSC and the implications model of Shan and Khan (2016) are a good combination of measuring sustainability performance of both internal processes regarding the production of an RI and the external performance of the product itself. However, based on the interviews and own research, it was observed that all MNCs are in the DJSI indicating the importance of assessing company sustainability performance by using different indices.

Regarding customer performance, the interviewees indicated that the NPS and customer surveys are used within current practices. Krol et al. (2015) underlined the combination of both NPS and customer surveys as the NPS reflects customer satisfaction to a limited extent. Next, other metrics such as the call rate, the complaint rate and the on-time delivery date can be added in order to measure customer satisfaction.

Table 7-1 Performance measurement framework RI in the healthcare sector. Metrics from Chiesa et al. (1996), Alegre et al. (2006) and Shan and Khan (2016).

Category	Type of metric	Metric
Financial	Accounting-based metric	ROE, ROA and ROS
		Revenue and its growth
		Sales margin
		Contribution margin
		NPV and IRR
		EBITDA
	Value-based metrics	MVA, EVA, SVA and CVA
		EM
		CFROI
Product innovation	Process – concept generation	Number of new product ideas
		Number of new products
		Product planning horizon
		Average product life cycle length
	Process – product development	Time to market (concept-to-launch time, time of redesign etc.
		Product performance (cost, technical performance, quality and cost-effectiveness)
		Design performance (manufacturing cost, number of redesigns, first pass yield etc.)

Category	Type of metric	Metric
Product innovation	Efficacy	Number of products that is replaced
		Extension of product range within main product field through new product
		Extension of product range within main product field through improved product
		Extension of product range outside main product field
		Number of environment-friendly products
		Market share growth
		Number of new markets opened abroad
		Number of new domestic target groups
		NPI-vitality
		Failure rate within 180 days
	Efficiency	Project innovation development time
		Number of innovation project working hours
		Cost of the innovation (cost effectiveness)
		Global satisfaction degree innovation project efficiency
Sustainability	Sustainability indices	DJSI
	SBSC	Energy usage during the production of the product
		Amount of waste during production of the product
		% of product that is recyclable
		Amount of emission during the production of the product
		Reduction of the use of hazardous materials
		Weight minimization
		Carbon footprint per employee
		Amount of jobs that is created in local areas
		Amount of support to local economies
		Amount of business opportunities that are created for local communities
		Safety of the employees
		Patient and staff safety
		Stakeholder engagement during the development of the project
		Improvement of local health
		Protection of local communities
	Sustainability implications	Improvement of local environment by preventing pollution
		Product recyclability
		Amount of environmental hazard such as noise, waste and emissions
		Cost-effectiveness
		Cost-to-benefit ratio for customers

Category	Type of metric	Metric
Sustainability	Sustainability implications	Affordability to the customers
		Improvement of basic living conditions
		Improvement about healthy lifestyle and customs
		Ensuring better health and well-being for the marginalized people of the society
Customer	Customer satisfaction	NPS (both patient and staff)
		Customer survey (both patient and staff)
		Call rate
		Complaint rate
		On-time delivery rate

From this framework, it is observed that some metrics overlap such as the number of environment-friendly products metric from the product innovation category that also takes into account sustainability. Therefore, it is important to note that these categories are not mutually exclusive. Furthermore, for sustainability three different types of metrics are discussed which are aimed at company sustainability, process sustainability and product sustainability.

7.3 Key findings and implications

Within this study, some key findings and implications were presented which will be discussed in this section. First, it has been identified that for financial performance, product innovation performance and sustainability performance, a combination of multiple types of metrics is useful in order to measure multiple aspects of the three categories. Second, the interviewees mentioned that customer metrics are used within the healthcare sector and in their business and therefore, this fourth category of customer metrics was added to the performance measurement framework.

Third, within these categories, different common reference point metrics were identified. For financial performance, the revenue and the sales margin are the common reference point. Regarding product innovation performance, cost optimization was observed to be the common reference point and for sustainability performance the metrics on environmental sustainability are a common reference point. In the case of customer performance, the NPS and customer surveys are a common reference point.

Fourth, the interviewees mentioned that within their MNC, they use the same metrics throughout the organization due to the fact that these metrics are based on the aim of the whole organization and that these metrics can easily be spread throughout the organization. Fifth, regarding RI, the interviewees mentioned that RI is not observed as a separate strategy but as a logical extension of developing and selling products in emerging markets. Due to the fact that there are similar demand in specific segments of developed markets, these products can be transferred to developed markets.

Producing products in and for emerging countries has a couple of advantages such as a better supply chain resilience, the availability of local knowledge and the ability to expand to the company's portfolio by reaching new markets within emerging countries. So as producing and developing products in developing and emerging countries has several advantages, MNCs will have less interest in developing products within developed countries for emerging countries which could explain the fact why there are less examples of weak RIs. Sixth, the interviewees indicated that they are not using the typology of Von Zedtwitz et al. (2015) questioning the use of this typology within MNCs.

7.4 Research contributions

Now that the sub-questions, the main research question, the key findings and the implications are discussed, the scientific and managerial contributions of this work will be discussed.

7.4.1 Scientific contributions

This study has a couple of contribution to the research on RI and performance measurement which are discussed in this section.

Scientific contribution 1: This research has identified the different types of performance metrics with its strengths and weaknesses for three different perspectives.

This study has thus contributed to the science on performance measurement as it compares different performance metrics in three different categories. By summarizing and comparing, a combination of methods is proposed that is able to measure multiple aspects of a company's performance. Therefore, researchers within the field of RI and performance measurement can use this comparison of performance metrics as a guidance or starting point in measuring the performance of RI.

Furthermore, the literature review of performance metrics in the these three categories provided a summary of the performance measurement methodology that is used in the daily management. Therefore, new research can use this summary of performance measurement methodology thus as a starting point to design performance measurement frameworks.

Scientific contribution 2: This research has provided a performance measurement framework for RI in the healthcare sector which can be used in future research

This research has contributed to existing literature on RI by providing a performance measurement framework than can be used to assess the performance of different types of RI. This framework thus provides a basis for future empirical and studies that can elaborate on this framework. Therefore, future studies could focus on measuring the performance of RI and its influence on the performance of the MNC in different markets.

In order to design this performance measurement framework, this research has relied on literature to a certain extent and data from current practices within the healthcare sector. However, this thesis provides a more comprehensive explanation on performance metrics and thus a more easy to understand performance measurement framework.

Scientific contribution 3: This research has shown how performance measurement is used in day-to-day business in MNCs that are operating in the healthcare sector.

Based on interview data, this research provides an interesting insight in performance measurement within MNCs that are operating in the healthcare sector. By identifying the methods that are used in the day-to-day business of MNCs the healthcare sector, different hypothesis can be formed which can be validated by quantitative data. Therefore, this research can be observed as a start for the research in performance measurement that is related to RI in the healthcare sector.

In addition, the importance of using performance measurement systems within current business is identified. The reason why these metrics are used within the MNC are also mentioned providing knowledge on the strategies of companies regarding performance measurement methodology. In future studies, the performance measurement methodology that is identified can thus be used in order to come up with new hypothesis.

Scientific contribution 4: This research has identified the process flow of RI and why RI is pursued within a MNC.

The interviewees indicated how RI is pursued within the company and why they are pursuing RI in this way. These reasons for pursuing RI are also in the first article related to RI by Govindarajan and Ramamurti (2011) indicating that the possible reasons that these authors provided can be confirmed by the MNCs that were interviewed. In order to find more reasons of pursuing RI, more interviews can be done. Furthermore, quantitative methods can be used to validate the reasons to pursue RI that the MNCs provided within these interviews.

By identifying the process flow of RI, the interviewees also provided reasons why they are pursuing strong RI. These reasons can also directly explain the fact why there are less examples of weak RIs as these reasons might explain why strong RI is more advantageous than weak RI. Therefore, this research provides an insight on how MNCs observe the different types of RI and future research can determine if the typology of Von Zedtwitz et al. (2015) will be used within MNCs.

7.4.2 Managerial relevance and contribution

The main managerial contribution of this research is the performance measurement framework for RIs in the healthcare sector. This performance measurement framework can be used in day-to-day management to reflect the performance of their business. Furthermore, the measurement framework and its metrics can also be used in decision making processes. As mentioned, the performance measurement framework can be used to measure the performance of their business on four different aspects and thereby, managers can determine in what aspect they are under performing and based on this under performance, they can make changes in their organisation or innovation approach.

Next, by interviewing different MNCs and product managers, a comparison between companies and their strategies, metrics and reasons for pursuing RI can be made. Therefore, the managers of these companies can learn from the knowledge that each company possesses and change their strategy accordingly. In addition, competitor analysis can be made based on a few of the metrics within the performance measurement framework in order to find gaps within the market.

Furthermore, this research can help managers in gaining knowledge on RI and the different strategies of MNCs that are familiar with RI. Therefore, these managers will be able to quickly assess their innovation process and use scientific knowledge to adjust their innovation process and strategy. Finally, this research shows that developing products within emerging countries has several advantages and that multiple MNCs were successful in producing a RI. Therefore, this research can convince managers to pursue a strategy that is based on producing products within emerging countries before transferring them to developed countries.

7.5 Limitations and recommendations

Limitation 1

First, the literature that was used for the literature analysis was obtained by using only Scopus and Google Scholar. Scopus was used as it is known to provide a better coverage of literature from emerging countries which are known for their RIs. However, Google scholar provides a lot of different hits when performing a literature study and therefore, it was difficult to find the right article. In addition, other literature search tools could be used such as PubMed, Microsoft Academic or Dimensions in order to find additional publications which are not covered in this research. Finally, the search terms were quite narrow and therefore, it could be that the literature analysis did not cover all literature publications.

Suggestion 1

Future literature analysis on performance measurement can use other types of analysis such as the bibliometric analysis or a bibliometric mapping in order to have a more quantitative approach to analyse the literature data. In addition, researchers can use broader terms to find data regarding performance measurement and different search tools cold be used. By using more search tools, additional publications can be found and used for literature analysis.

Limitation 2

The performance measurement framework in this research has not been validated. The performance measurement framework has been designed based on interview data and literature analysis. Four different interviews were conducted with four different MNCs that produced an RI. However, there are more MNCs that produced multiple RIs and therefore, it could be that these MNCs use for example different metrics in relation to product innovation performance or sustainability performance.

Suggestion 2

The performance measurement framework can be validated by performing more interviews or questionnaires with MNCs that are working with RI in the healthcare industry. Furthermore, within performance measurement, there are a lot of different categories. For this research, four categories are selected as a good reflection of performance within the healthcare sector. Additional interviews with other companies can be performed in order to validate these categories as useful categories for MNCs within the healthcare industry.

Limitation 3

In relation to generalizability, this study is has only taken into account MNCs that are developing RI within the healthcare sector. The study showed that these companies are using the same metrics throughout the organization. As the interviewees are all part of healthcare companies, it is difficult to generalize this performance measurement framework to other industries.

Suggestion 3

With relation to generalizability, this research can be extended to other industries if the four perspectives that are used for this performance measurement framework are also important for other industries, the performance measurement framework can be used in other industries. However, in order to find this out, different interviews have to be performed with managers from other industries that have produced RIs.

Limitation 4

As already mentioned in the previous chapter, the interviewees did not mention that many examples of product innovation performance and sustainability performance indicating that the interviewees did not had the knowledge on all aspects of performance measurement. Therefore, interviewing different interviewees from different departments would have been a better method to cover all aspects of performance measurement. For example, an interviewee from the R&D department, an interviewee from the sustainability department and the product manager.

Suggestion 4

In order to obtain more data regarding performance measurement within the different MNCs, interviews with employees from different departments can be done. Furthermore, the interviewees indicated that the metrics are designed by special teams and therefore, it is interesting to interview the people in those special teams. Another solution to obtain more data regarding performance measurement is to handout a lot of different metrics and let the interviewees indicate which ones are used within their MNC.

Limitation 5

In this thesis, only MNCs from developed countries were taken into account due to the fact that there were only a couple of MNCs from emerging countries that developed RIs. Therefore, the insight of MNCs from emerging countries is not taken into account in this research. Furthermore, only successful RIs are described within this research which means that the negative aspects of RI are not discussed in this research. Therefore, the fifth limitation of this research is that the framework does not integrate any negative or unsuccessful practices of RI.

Suggestion 5

Future research should focus on both MNCs from developed countries and emerging countries to identify more examples of RI and also less successful examples of RI. By identifying less successful or unsuccessful examples of RI, the challenges that come along during RI processes can be identified which could be useful knowledge for managers.

Additional suggestions

The performance measurement framework that is designed in this research can be used in future research to assess the performance of the different types of RI. By assessing the performance of the different types of RI, researchers can identify which type is more successful which could help managers

in deciding which type of RI to pursue. Furthermore, knowledge about the performance of the different types of RI can help both EMNE and DMNE ensuring the effectiveness of their investments.

Next, the interviewees provided some reasons for pursuing RI which match the possible reasons that were mentioned by Govindarajan and Ramamurti (2011). Therefore, future research should focus on determining the reasons of pursuing RI and thus confirm the research of Govindarajan and Ramamurti (2011). This research can be observed to be a starting point as the interviewees already mentioned a few reasons of pursuing RI. However, quantitative data is required to confirm these findings.

Finally, the interviewees provided several reasons for pursuing strong types of RI and the interviewees were not aware of weak types of RI. Therefore, future research should find out of weak RI can be used as a strategy and if the typology of Von Zedtwitz et al. (2015) is used within the management of RI by MNCs from both developed and emerging countries.

7.6 Reflection

In my search for a topic for my master thesis research, I was looking for topic that was closely related to innovation and strategy. During the course Leadership and Technology Management at the beginning of the study year, I came along the subject of frugal innovation which directly took my attention. So when looking for a master thesis project at the same time, I found the opportunity to pursue a research on RI which is closely related to frugal innovation and I directly took this opportunity.

Initially, the goal of this research was to design a performance measurement framework and use this framework directly to measure the performance of both weak and strong types of RI. However, whilst conducting this research, some difficulties were encountered. First, I was not able to identify a lot of different weak types of RI. Second, it was difficult to get in contact with different MNCs and find the right person to interview. Third, it was difficult to find detailed information regarding the performance of the MNCs as interviewees were reluctant to provide detailed information on for example their financial performance.

Therefore, the scope of this research changed to only strong types of RI as the MNCs that were interviewed only produced strong types of RI. In addition, the objective was changed in order to be focused on the production of a performance measurement framework rather than using this performance measurement directly to measure the performance of both strong and weak RI.

Next, I would have done a couple of things different regarding the methods of this research. First, I would have contacted more MNCs in the healthcare sector that have or have not produced RIs in order to identify new examples of RI. Furthermore, I would have included more interviews with different employees from multiple MNCs. For example, employees from the R&D department or the sustainability department. However, contacting MNCs and finding suitable interviewees is a time consuming process and the likelihood of finding the desired interviewees is not likely.

This research was performed in the fulfilment of the master degree in Management of technology. This research was therefore relate to the aim of the master degree which is to educate students on the management of businesses, innovations and technologies in a wide range of markets. In order to manage innovations and your business, performance measurement is observed to be an useful tool. Therefore, this research is directly connected to the aim of this degree. Furthermore, RI is a novel concept in the field of innovation and their typology and therefore, it is interesting to compare RI with

other types of innovation and their characteristics. Finally, this research is related directly to different courses of this master degree (table 7-1)

Table 7-2 Courses of Management of Technology that are related to this research

Course	Related concepts
MOT2313 Research methods	Research methodologies
MOT2004 Preparation for the Master thesis	Introduction
MOT1524 Leadership and technology management	Frugal innovation and innovation management
MOT1435 Technology, strategy & entrepreneurship	Different types of innovations and the diffusion of those innovations

Appendix A – Background innovation

Innovation as a concept

Nowadays, the term innovation can be described in many ways as there are many different disciplines in which it can be used (Baregheh, Rowley, & Sambrook, 2009). For example, Schilling (2017) described it as "the practical implementation of an idea into a new device or process" (p. 19) while others expand this definition with the fact that an innovation adds value for customers or enterprises (M. Rogers, 1998). Despite the fact that there is no clear definition for innovation, it became one of the most important drivers of competitive success in recent years as one-third of the profit of firms in different industries is made by the sales of products developed within the past five years (Schilling, 2017).

Further, innovations can be divided in a lot of different types such as product versus process innovation in which product innovations are outputs of enterprises which can either be services or goods and process innovations are innovations regarding the way of how companies organize business (Schilling, 2017). Moreover, a distinction can be made between radical and incremental innovation which involves the level of newness or differentness towards existing products and processes (Dewar & Dutton, 1986). Furthermore, architectural and component innovation can be distinguished referring to the product as a whole or the products in its parts (Henderson & Clark, 1990).

There are thus a lot of different types and processes of innovation which resulted in large amounts of literature describing innovativeness and approaches towards the different innovation processes. Furthermore, there is a shortage in consistency in the use of terms such as innovation which resulted in the widespread confusion about what different studies are actually reporting (Garcia & Calantone, 2002). Therefore, this chapter provides an insight in the theory of innovation and it provides the definitions that will be used for this research.

What is innovation?

As mentioned in the previous section, the term innovation can be described in many ways but the most important notion is that there is a level of novelty related to it. In order to reduce the magnitude of different meanings of innovation, this thesis will relate to technological product innovations to categorise different RIs as it "best captures the essence of innovations from an overall perspective" (Garcia & Calantone, 2002, p. 112).

Technological innovation as a concept relates to the concept of an iterative process that is initiated by the impression of a new market or new service opportunity. This new opportunity will lead to the development, production and marketing to aim for commercial success of an initial idea (Garcia & Calantone, 2002). From this definition of the technological innovation perspective two important notions are identified. First, innovation is a continuous iterative process which thus implies that there are different degrees of newness or innovativeness. Second, innovation is a technological development of an idea or invention which leads to market introduction to consumers through adoption and diffusion (Garcia & Calantone, 2002).

The iterative nature of innovations is a basis for different innovation types such as radical innovations and incremental innovations. This typology is the result of the research of Utterback and Abernathy

(1975) in which the emphasis on different aspects of product innovation shifts during the iterative process of innovation. First, the emphasis lies on the performance of a product, then on the product variety and in later stages, product standardization and costs become more important (Utterback & Abernathy, 1975).

The emphasis on the different aspects of product innovation can thus be linked to a degree of 'innovativeness' which is a measure of 'newness'. However, this concept of newness can be linked to different perspectives such as "new to the world, new to the adopting unit, new to the industry, new to the market and new to the consumer" (Garcia & Calantone, 2002, p.112). Due to the fact that there are thus differences in unit of analysis of newness, it is difficult to compare different studies. However, innovativeness and their different perspectives always describe innovation as a discontinuity and therefore innovativeness can be observed as a measure of potential discontinuity (Garcia & Calantone, 2002). Additionally, there are different discontinuities based on the technological, market, political and other foundations which require different management approaches (Phillips, Lamming, Noke, & Bessant, 2004)

The second notion mentioned in the definition of a technological innovation is that an idea or invention will lead to market introduction to consumers through adoption and diffusion. It is thus important to note that as long as an idea or invention is not produced and marketed, it has not become an innovation (Garcia & Calantone, 2002). This means that an invention or an idea remains an invention or an idea if it has not surpassed a laboratory setting meaning it has not an economic contribution or value. Therefore, R&D is not the only key to innovation but also the manufacturing, marketing, distribution and improvement of this innovation are relevant.

Innovation and its description are complex and there are various different perspectives towards the dimensions and constructs of innovation. This thesis will use the classification provided by Wehn and Montalvo (2018) who based their work on the three dimensions that were used in the research by Gopalakrishnan and Damanpour (1997). A fourth dimension was added which is the measurement of innovation in impact and assessment terms which is an important feature of this thesis (Wehn & Montalvo, 2018). These different dimensions will now be discussed as these will be useful for the understanding of RI (Figure 2.1).

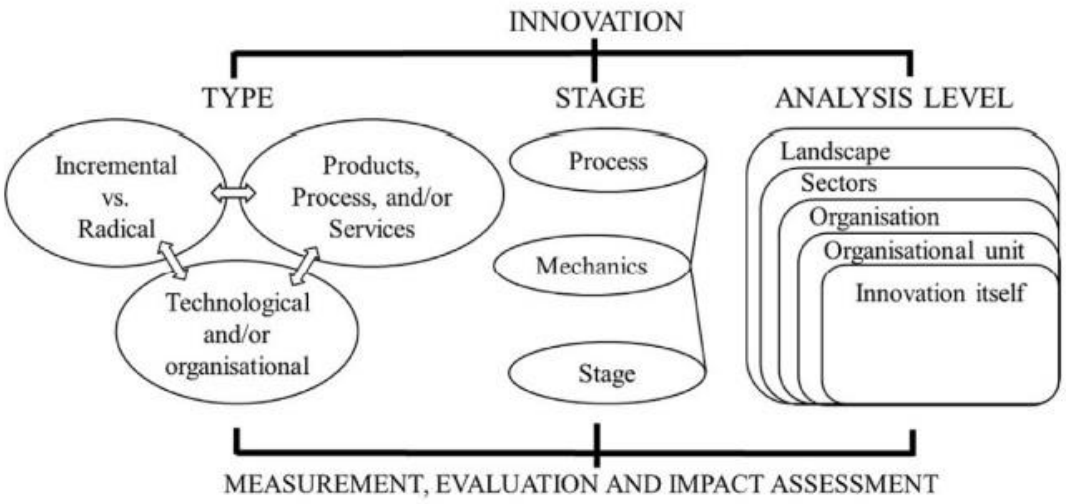

Figure A.1 The dimensions of innovation. From *Exploring the dynamics of water innovation: Foundations for water innovation studies* by Wehn and Montalvo (2018, p.S5)

Dimensions of innovation

So according to When and Montalvo (2018), there are four different types of dimensions. The first dimension is the stage of the innovation process, the second dimension is the level of analysis, the third dimension is the type of innovation and as mentioned, the final dimension is the impact assessment of an innovation (Gopalakrishnan & Damanpour, 1997; Wehn & Montalvo, 2018). In this section the same order as Gopalakrishnan & Damanpour (1997) is used.

Stage of the innovation process

During the process of innovation, several stages are encountered which consists of the start of an innovation with a new idea to the diffusion of the innovation. Therefore, the stages of the innovation process analyses every step of action of an innovation (Gopalakrishnan & Damanpour, 1997; Wehn & Montalvo, 2018).

The whole innovation process or cycle can either be linear or non-linear. In a linear model, these stages occur in a sequential linear fashion. In a non-linear model, the stages and process are described to be complex and non-sequential (Gopalakrishnan & Damanpour, 1997). In general, two clusters of stages can be identified: the development of innovations which refers to technology push and the adoption of innovation which refers to market pull.

In terms of the development of an innovation, most innovations stem from specific problems or social demands. Therefore, there are two mechanism that are needed to act on those problems which are the decision making process and structure of a company and the actual capacity of problem solving and integrating knowledge (Montalvo, 2006). This limits the initial stages of an innovation towards: ideation, definition of priorities in problem solving, conducting basic research, applied research for prototyping, testing, upscaling production and marketing (Wehn & Montalvo, 2018).

The second cluster of stages is the adoption of an innovation which refers to “the phases of acquisition by and integration ins users’ behaviour, service and support and wide use” (Wehn & Montalvo, 2018, p. S8). In the stage of adoption, two effects of change can be experienced. First, changes in organisations refers to for example new skills, creation and destruction or new organisational layouts. Second, changes are experienced at a broader societal level which consists of for example changes in behaviour, consumption patterns or life styles (Wehn & Montalvo, 2018).

Levels of analysis

By the level of analysis, “researchers consider diverse aspects of the governance of innovation in reference to the context and level of aggregation where change takes place or has taken place” (Wehn & Montalvo, 2018, p. S8). There are five types of levels which are the innovation itself, the organisational unit, the organisation, the industrial sector and the landscape. Research in each of these levels will provide different insights in how to deal with innovation in terms of for example decision making and the capacity of firms to quickly learn and adapt to changes in different levels. Therefore, the different levels of analysis will provide different findings and implications.

Type of innovation

As already mentioned in the beginning of this chapter, there are different types of innovation. The types correlate with answers to the question: what is new? and what is changing or has changed? There are three different types that can be recognised.

First, there is a difference between radical and incremental innovations which refer to the level of newness or innovativeness. Incremental innovation is characterised by a low level of newness and consists of marginal changes in different fields such as upgrading existing knowledge and skills or services (Dewar & Dutton, 1986; Wehn & Montalvo, 2018). Radical innovations in contrast are disruptive in their nature and can transform entire industries (Tushman & Anderson, 1986). Incremental and radical innovation is observed to be the starting point of innovation typology as either of the other types of innovation such as process/product innovation can be radical or incremental.

The second typology of innovation is the distinction between product, process and service innovation. Product innovation refers to the development of a new product from new knowledge, materials or the recombination of other innovation and is aimed at fulfilling client preferences (Gopalakrishnan & Damanpour, 1997). These product innovations are often a result of a process innovation which refers to changes in one or several aspects of a manufacturing process (Tushman & Anderson, 1986; Utterback & Abernathy, 1975). Service innovation is different of both product and process innovation in the sense that there is no creation of a tangible artefact. Therefore, service innovations is defined as a change that affects one or more innovation types and/or inherent competences (Wehn & Montalvo, 2018).

Third, organisational and technological innovation are divided. As mentioned in the beginning of this chapter, this thesis will use technological product innovations to categorise the different types of RI. However, it is important to take into account organisational innovation which consists of changes in the organizational structure or administrative processes that could lead to the development of a new RI product (Gopalakrishnan & Damanpour, 1997).

Appendix B – RI examples

Table B-1 displays the examples of RIs. The column on diffusion shows which of the phases that Von Zedtwitz et al. (2015) identified took place in a developed/advanced country (A) or took place in a developing/emerging country (D). For some examples of RI, the diffusion and thus the type of RI is unknown (N/A)

Table B-1 Examples of RI

Product	Company	Diffusion	Type of RI	Source
Ultrasound Elast PG	Philips	DDDA	Strong	(Von Zedtwitz et al., 2015)
MAC 400	GE	DDDA	Strong	(Von Zedtwitz et al., 2015)
Oncovin	Eli Lilly	DAAD	Weak	(Von Zedtwitz et al., 2015)
Essenta RC	Philips	N/A	N/A	(van Kleef, 2020)
Essenta RAD	Philips	N/A	N/A	(van Kleef, 2020)
Lullaby Warner	GE/Wipro	DDDA	Strong	(Hoekman, 2018)
Lullaby LED Phototherapy	GE/Wipro	N/A	N/A	(Hoekman, 2018)
Multi X Select DR	Siemens	DDDA	Strong	(Hoekman, 2018)
SomaTom Smile	Siemens	N/A	N/A	(Hoekman, 2018)
SomaTom Spirit	Siemens	DDDA	Strong	(Hoekman, 2018)
SomaTom Scope	Siemens	DDDA	Strong	(Hoekman, 2018)
The Brivo CT235b	GE	DDDA	Strong	(Hoekman, 2018)
Revolution ACT	GE	DDDA	Strong	(Hoekman, 2018)
VISIG	Philips	DDDA	Strong	(Hoekman, 2018)
BV Vectra	Philips	N/A	N/A	(Hoekman, 2018)
ClearVue	Philips	N/A	N/A	(Hoekman, 2018)
Jaipur-Knee	Equalize Health (Former D-Rev)	AADA	Weak	(Hadengue et al., 2017)
Pacemaker (Pill)	Medtronic	N/A	N/A	(Hadengue et al., 2017)
CT Scanner	Toshiba	ADDA	Strong	(Hadengue et al., 2017)
Multiple medical devices	Mindray	N/A	N/A	(Hadengue et al., 2017)
DengVaxia	Sanofi Pasteur	N/A	N/A	(Smith, 2018)
Medical drones	Zipline	AADA	Weak	(The Medical Futurist, 2019)
Leveraged freedom chair (LFC)	GRIT	DADA	Strong	(The Medical Futurist, 2019)
Brilliance	Equalize Health (Former D-Rev)	DADA	Strong	(The Medical Futurist, 2019)

Cholestech LDX	Abbott	N/A	N/A	(Konwar & Borse, 2020)
Cobas H232 POC System	Roche	N/A	N/A	(Konwar & Borse, 2020)
Myopilux lense	Essilor	DDDA	Strong	(Hadengue, 2017)
Ready to clip lense	Essilor	DDDA	Strong	(Hadengue, 2017)
Azio lense	Essilor	AADA	Weak	(Hadengue, 2017)
India lense	Essilor	AADA	Weak	(Hadengue, 2017)
HiSpeed Dual	GE	DDDA	Strong	(Sinha, 2013)
Eurartesim	Sigma-Tau	DADA	Strong	(Ubben & Poll, 2013)
CRADLE VSA	Microlife	AADA	Weak	(Firoz, Makanga, Nathan, Payne, & Magee, 2017)
Versana Premier	GE	DDDA	Strong	Interview
Versana Balance	GE	DDDA	Strong	Interview
Versana Essential	GE	DDDA	Strong	Interview
Versana Active	GE	DDDA	Strong	Interview
PrimaryDiagnost	Philips	DDDA	Strong	Interview
DuraDiagnost	Philips	DDDA	Strong	Interview

Appendix C – Email Layouts

#1 Interview invite

Dear [name],

Please allow me to introduce myself. My name is Gido Drewes, and I am a graduate student in Management of Technology at Delft University of Technology, Netherlands. I am contacting you as an expert in the field regarding my research on reverse innovation in the healthcare sector and I would be grateful if you could participate in this research.

As an overview of my research, reverse innovation (RI) is where an innovation transfers from a developing country to a developed country during the innovation process. The focus of my thesis is to design a performance measurement framework for reverse innovation on three different aspects: financial performance, product innovation performance and sustainability performance. This includes a literature study on performance measurement on these three aspects to identify the strengths and weaknesses of different performance measures and interviews with managers working with current practices of RI.

I believe your expertise is very valuable for this research and I am very keen to have your insights on the topic. As such, I would like to invite you for an interview. Your expert opinion on performance measurement in the context of RI will help me understand what types of measures and metrics are used to assess the RI process and what the performance of different types of reverse innovations is.

To achieve my goal, I would like to schedule about a one-hour interview at your convenience in May. If preferred, your profile will be kept anonymous and only with your permission, the interview will be recorded. After the interview, the transcript will be sent to you for your verification. A key deliverable of my research is a performance measurement framework for RI on the abovementioned aspects which is instrumental for managers in evaluating their RI initiatives. I will be pleased to share with you the results of this study once my thesis is complete.

Should you be unavailable, I would highly appreciate if you could kindly connect me to anyone else in your company or from your network who I can interview regarding my research on reverse innovation. Thank you in advance for taking the time to discuss my research.

Kind Regards,

Gido Drewes

LinkedIn: Gido Drewes
g.drewes@student.tudelft.nl
gido.drewes@gmail.com

#2 Interview invite

Dear [name],
Please allow me to introduce myself. My name is Gido Drewes, and I am a graduate student in Management of Technology at Delft University of Technology, Netherlands. I am contacting you as an expert in the field regarding my research on reverse innovation in the healthcare sector and I would be grateful if you could participate in this research.

Reverse innovation (RI) is where an innovation transfers from a developing country to a developed country during the innovation process. In the case of ….., the ….. is an example of a reverse innovation as it is developed in …. and now sold in different regions around the world. Therefore, I am particularly interested in the development of this device.

The focus of my thesis is to design a performance measurement framework for reverse innovation on three different aspects: financial performance, product innovation performance and sustainability performance. This includes a literature study on performance measurement on these three aspects to identify the strengths and weaknesses of different performance measures and interviews with managers working with current practices of RI.

Could you kindly connect me to anyone in your company or from your network who I can interview regarding my research on reverse innovation. If preferred, your profile will be kept anonymous and only with your permission, the interview will be recorded. After the interview, the transcript will be sent to you for your verification. A key deliverable of my research is a performance measurement framework for RI on the abovementioned aspects which is instrumental for managers in evaluating their RI initiatives. I will be pleased to share with you the results of this study once my thesis is complete.

Kind Regards,

Gido Drewes

LinkedIn: Gido Drewes
g.drewes@student.tudelft.nl
gido.drewes@gmail.com

#3 Introduction to interview

Dear [name],

I am thankful that you are able to participate in my MSc thesis research. The focus of my thesis is thus to design a performance measurement framework for reverse innovation on three different aspects: financial performance, product innovation performance and sustainability performance. In order to design this framework, literature study will be combined with interview data.

The interview will take about an hour. If preferred, your profile will be kept anonymous and only with your permission, the interview will be recorded. After the interview, the transcript will be sent to you for your verification. A key deliverable of my research is a performance measurement framework for RI on the abovementioned aspects which is instrumental for managers in evaluating their RI initiatives. I will be pleased to share with you the results of this study once my thesis is complete.

In the enclosure, you can find the questions for the interview and related literature.

Kind Regards,

Gido Drewes

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gido.drewes@gmail.com
g.drewes@student.tudelft.nl

Appendix D – Interview questions

A.1 General questions on RI

- What is your definition of RI?
- Based on your definition, how many RI initiatives the company currently pursuing/developing
- Could we please go through each of the initiatives?
- What are the main Reasons for pursuing RI?

A.2 General questions on performance measurement

- Do you currently have any performance metrics developed and used for RI initiatives? If yes, what are the indicators/metrics that you use? Do you have a list?
- Why are you using these specific metrics?
- How are these metrics developed?
- Are the metrics categorized into certain aspects? If yes, what are the categories?
- What metrics/measures/indicators or categories do you think are relevant in the future?

Back-up questions

B.1 Questions on financial performance

- Which indicators or metrics are used to measure financial performance of RI initiatives?
- Why are these specific indicators/metrics used?
- Are these indicators/metrics used as forward-looking (decision making) or backward-looking (assessing performance) metrics?

B.2 Questions on product innovation performance

- Which indicators or metrics are used to measure product innovation performance of RI initiatives?
- Why are these specific indicators/metrics used?
- Are these indicators/metrics used as forward-looking (decision making) or backward-looking (assessing performance) metrics?

B.3 Questions on sustainability performance

- Which indicators or metrics are used to measure sustainability performance of RI initiatives?
- Why are these specific indicators/metrics used?
- Are these indicators/metrics used as forward-looking (decision making) or backward-looking (assessing performance) metrics?

Interview Roche

A.1 General questions on performance measurement

- Do you currently have any performance metrics developed and used for healthcare initiatives? If yes, what are the indicators/metrics that you use? Do you have a list?
- Why are you using these specific metrics?
- How are these metrics developed?
- Are the metrics categorized into certain aspects? If yes, what are the categories?
- What metrics/measures/indicators or categories do you think are relevant in the future?

A.2 Performance metrics on innovations for developing countries

- I am wondering if there are healthcare initiatives in developing countries pursued by Roche? If yes, is there any plan on selling these healthcare initiatives in developed countries?
- If Roche is not planning to sell these initiatives in developed countries, why is that the case?
- What are the barriers?

Can I come back to the metrics that you mentioned for healthcare initiatives

- Can you relate these metrics to healthcare initiatives for developing countries
- Can you relate these metrics to RIs (for example the H 232)
- Can I ask you how would you define RI and do you consider RI as a potential strategic approach for Roche?

Appendix E – Interviews

E.1 Interview GE

Date of online interview: May 13th, 2021, 07:00 AM (CEST)
Interviewee: Global Product Manager at GE Healthcare
Language: English
Before the start of the interview, an agreement was made to record the interview and to make a transcript for verification.

What is your definition of RI?
The first time when I got in touch with this concept, it was from a case study from the Harvard Business Review which was talking about the RI from GE and it was telling a story about how we are developing ultrasound products in our Wuxi site. That was the first time, I got familiar with this concept and from that case my definition and my understanding is that we started our business from china, from India and other developing countries. During that period we saw some potential markets in those developed countries where we can sell our product too because those customers, might use our product in different scenarios and their clinical requirements are similar to the customers in China, India and other developing countries. So my understanding to this concept is that we start our business from developing countries and for those developing countries and later we found that we can expand our footprint to other regions based on the same product or the same design.

Based on your definition, how many RI initiatives are the currently pursuing?
So I am working in Ultrasound business and therefore I am more familiar with ultrasound devices. So what we are developing in Wuxi, is for example the value ultrasound portfolio as I mentioned which is targeting primary care customers and the other one is that we also have laptop systems for the point of care market. The next one is that we are developing cardiac ultrasound systems in China. These three are the main business in Wuxi now and on top of that we also have seen other products that are developed in Wuxi for example the ABUS system which is the automatic breast ultrasound system which is used to screen breast cancers. So we are developing and manufacturing more and more products right now in Wuxi. If we talk about the RI, it is mainly about our primary care ultrasound because we started this business from Wuxi and expanded it to other regions. For most of the other ultrasound products, we started the business in other regions but we are now moving those to china due to the fact that we have a big market in China and we also have a more efficient position and supply chain in China and therefore, these products should not be considered to be an RI.

Can you give me clear examples of devices that are RIs?
I will type the names of those devices in the chat:

- The Versana Premier
- The Versana Balance
- The Versana Essential
- The Versana Active

So in the chat window, you can see four products models that we are developing now which are now sold globally. These are the main stream offerings that we are providing to the primary care market.

So according to the article of Von Zedtwitz et al. (2015), there are four different phases of innovation. Can we go through these four examples and the four phases?

So here, let me introduce you to our team. First of all, me as the product manager, I am based in Beijing China, and I have two product managers within my team. One is based in Wuxi, China and the other one is based in Singapore. Usually, when we have new ideas for a new product, it is up to us to generate those new ideas and of course we have internal discussions with different functions and even the commercial leaders from different regions. When we have solid ideas, we will go to the engineering team and see the technical feasibility. Hereafter, we need to define the program and then we are going to communicate to the development departments and all those departments are based in Wuxi. We have less than 60 engineers in Wuxi that are carrying the full functions including the mechanical, hardware, software and even the system which is the image quality. After that, we have manufacturing engineers who are helping us to convert that R&D into production. This is how we are organising our internal product development.

So if I understand it correctly, Ideation takes places across the whole world as it has influences from different regions and countries?

Yes, so if we go back to 2014, if we talk about this topic, I believe that the most input comes from developing countries such as China, India, South-America, South-East Asia and even Africa. Those regions are contributing for almost 80% of my business. When we have new products to define, and when we are generating those ideas. We need to have discussions with almost all regions to make sure that this idea is applicable to all regions. For example, USA and Europe is contributing almost 50% of my revenue and for the other regions this is quite similar. At least for the primary care business, we don't have two big regions as every region has a revenue of 10 million or more. Therefore, we have big meetings to discuss ideas before we develop new products.

If we take a look at the market perspective for those innovations, are they first sold in emerging countries or are they first sold in developed countries?

From our sight, we are selling most of our products to developing countries. China and India are the biggest regions to me as for example China has a market size of 300 million and India has a market size of 100 million of our total market size of 1 billion. So these two countries are still very big and from our sight, the primary market are the developing countries such as China, India and other South-East Asian countries. However, it remains difficult to define the primary market but what I can tell you that our secondary market is East-Europe, North-Europe as well as Canada. Our solutions are still quite not developed for our business and we still have some resource challenges in those markets.

What are the main reasons for pursuing RIs?

This can be divided in two aspects. Why do we develop products in China and for China? Why do we sell those products in developed countries? First, we develop those products in China and for China due to the fact that China is our biggest market and so if we have the development team in China, it will be close to our biggest market. Second, primary care customers are very sensitive to price which means that for such products we need to have a lower price and thus a lower cost. In China we have more local supplies available. For example in our Wuxi site, 98% of our suppliers are within a one-hour driving distance and so our supplies are more reachable. Therefore, we can have lower cost and on the other hand we can have better supply chain resilience. For example, last year we faced big challenges due to Covid and this year we faced semiconductor component shortages but since our supplies are close to our manufacturing device, we were able to ship those components very easily to our

manufacturing site. Third, we develop products in China due to historical reasons. We started our business 15 years ago in Wuxi and we have shown that the engineers in Wuxi have been pretty mature on the development of those products. They also have been quite familiar with this type of customers, their clinical needs and the challenges the needs the customers face. So to conclude, we develop products in Wuxi for three reasons: First, we are close to our biggest market, second, we are close to our supplies and third, the team in Wuxi has shown to be mature in the primary care industry.

What are then the main reasons to sell those products in developed countries?
In the beginning, I took this role in 2014 and in this period, the developing countries were our top priority and we had little business in developed countries. But when I revisited the market size data, I found that in those developed countries, there are huge market sizes but we almost had nothing for our business in those countries. This is not quite align with our gut feeling and on the other hand I visited those customers in developed countries. I found that in those developed countries for example Germany, have a lot of private customers, private clinics and private hospitals. Of course, our high-end systems with a lot of features can help the academic research but this is not something relevant for those customers. For those customers, they are mainly using the ultrasound systems to make some basic scans and basic diagnostics and if they cannot see any lesions very particularly, the private clinics can refer their patients to higher-end hospitals. At the same time, those customers are quite sensitive to the price because they need to take care of their ROI. This is something that I saw in Germany, United States, Japan and many other countries. From their side, due to the ROI concerns, they do not want invest a lot of money in high-end ultrasound equipment and on the other hand their clinical uses are not quite deep and so we can definitely use the same product for those customers. The last one from my side and usually those customers use ultrasound as a visualizing tool for them to make their diagnosis and for them ultrasound is not their job. So usually, they are not that skilled on ultrasound scanning and diagnosis and so they don't need a lot of additional features to help them with diagnosis and they don't very high image quality and so our primary care products can fulfil their needs by 100%. Of course, we need to take care of other designs as most of the clinics are private practice and they get their reimbursement from the insurance companies and those insurance companies have very strict protocols to follow. In China and India, they do not have very strict protocols. Therefore the product is already there but we need to work on minor changes for our products such as the patient management system, with those minor changes we can fulfil those customers and why shouldn't we do that. By making those minor changes, we make sure that our product can be accepted by both customers in developing and developed countries. However, not all customers, we still need to have the patients across all the customers in the developed countries for example those hospitals and clinic institutes are not our customers as they require advanced features for the quantitative analysis. So these are not our customers and we are focusing on specific segments.

One additional point, Usually when we are considering those developed countries, the model we are using is simple for example, this country is a developed country and their healthcare system is driven by private clinics. An example is the United Kingdom, where the healthcare system, the NHS, is very established with less private clinics. Therefore, we need to make a detailed analysis for each country to have a holistic understanding of their healthcare system and if we can find the customers we are targeting. We cannot expect that in a country all the customers are the same with the same affordability, the same clinical usage and the same challenges to meet every day and therefore customer segmentation is very important. For example, the United Kingdom, our business there was small because based on our analysis the NHS focused on the purchase of high-end products and therefore even in the private sectors, they require high quality care as they need to provide detailed

diagnosis and treatment by themselves. So our primary care products cannot fulfil those requirements and therefore we cannot sell our primary care products in every countries but we can find some segments were we can.

Do you currently have any performance metrics developed and used for RI initiatives? If yes, what are the indicators and metrics that you use? Do you have a list?
From my side, most of the decisions we made to leverage of Wuxi, were made 15 years ago and we are not revisiting those decisions as the Wuxi site has proved itself as a very successful manufacturing centre and now we are moving more and more products to be manufactured and developed in Wuxi. This is proving the success of this model. From my side, when I got the email from you asking about this interview about the RI, the first thought was the revenue distribution of the different regions on how to measure the success of RI.

Do you use KPIs to make decisions or measure performance?
Yes, sure, in our daily practices. You may have heard from the news since a year we have been leveraging LEAN methodology in our daily management and we are using the same metrics across the GE company to measure the performance of each business. For example, we have a few level 1 metrics such as the revenue and orders and their growth rates and besides this, we also use the new product innovation (NPI)-vitality which are the orders of NPI products released within one year and its portion across the entire portfolio revenue and the entire portfolio orders. Another example is, we also are interested in metrics related to quality such as the failure rate within the first 180 days and the on-time delivery date to fulfil our customers, but also how we are saving the cost across the entire portfolio and business. Besides these, we are also interested in our sales margin and contribution margin. We have some series of metrics to measure our day-to-day business and we have a monthly calendar to review the performance level per level; for example I am reporting to the general manager from our business and I have to present how our business is going following all those metrics. Every year we set a target by quarters and even by month and when we have the numbers, and if we meet our targets, we can explain by what we are doing to achieve that. But when we don't meet our targets, we need to analyse what are the key drivers and what are our corrective measures to turn these over. So we have a lot of metrics, we have been using in our daily management.

So the main reason you are using those specific metrics is due to the fact that they are used across the whole company?
Yes, that's true and from our side, this is a good reflection of how our business is going on because as from our side, we are mainly focusing on the revenue and orders. Those metrics are important but it cannot tell us everything. So on the first hand, we need to take care of the business growth but on the other hand but we also need to take care of customer satisfaction and we need to take care on how we are spending our money: is it effective or not? So we need all those metrics to show us the whole picture on how the business is going.

Do you know how those metrics are developed or do you use a specific method to develop those metrics?
Those metrics have been changed the past years, in 2019 when we developed a new set of metrics. Those new metrics were developed by LEAN coaches that worked together with different business teams. In the beginning of last year, we changed to metrics by removing metrics and adding new metrics that measure the performance of the whole business better and even in the beginning of this

year, we made some changes to the metrics. However, the framework is still there and only small changes are made.

So those metrics have been changed continuously?

Most of the metrics have been used the past years but some metrics have been changed over the years as some metrics are not relevant anymore. For example, we have been tracking the product failure rate for the first year, the first 180 days and the first 90 days. We decided to remove the failure rate for the first year and the first 90 days and keep the failure rate for the first 180 days because we found that this metric better reflects the performance of our business and prevent duplicates.

Are those metrics categorized into certain aspects? If yes, what are the categories?

We have level metrics which are categorized a little bit into the general business outline, sales and customer satisfaction for example the on-time delivery date, the infant failure rate and the customer satisfaction rate we obtain from the market. A final category is the business efficiency, we are interested in how we are spending our money and for example the variable cost we are spending on shipment and interests. Besides, we have some metrics aimed people which are not focused directly on the business but we are tracking it such as the safety and the diversity in our company. So usually, we have some business metrics and some team metrics. For the business metrics, we have different focuses on the income, on the spending, and on the customers interests.

What metrics/measures/indicators or categories do you think will be more relevant in the future or are becoming relevant for RI?

So for the RI, we use the same measures as for our daily business. As most of my business is focused on leveraging RI and so we can see how this business is growing and how our market share is growing. So even for the products, the costs are going down year by year and this is something we can compare. For the other business related to ultrasound, we can use the same metrics. For example, the patient monitor system is developed in USA or Europe and in that case, we can make a comparison of their business and the business we are pursuing in Wuxi.

Which indicators or metrics are used to measure financial performance of RI initiatives?

We are currently using financial metrics such as the revenue and orders, and their growth rates. As I mentioned, the second is the portion of revenue that comes from NPI. Third, the margins are measured such as the contribution margin and the sales margin.

Are they mainly used as a forward-looking approach (decision making) or a backward-looking approach (assessing performance)?

We are mainly using those backward looking parameters to indicate if our decisions were made correctly and on the other hand, every year we have two sessions in which we use forward-looking measures to make a plan on how we are spending our money and how are business will look like. In these discussions, long-term planning strategic decisions are made. In those metrics, we mainly look at basic metrics such as the market size by different regions, by different applications and by different segments. The second type of metrics are about how the market size will be growing and if this market is growing, an opportunity for investment will arise. These metrics are quantitative but we also have qualitative metrics for example, the evolving of the technology and the costs. For example, the price of shipment is going up and so are our costs. Therefore, we need to make changes in order to reduce costs. So on our daily basis we are using backward-looking metrics and once or twice in the year we use a more forward-looking approach.

What do you use to measure the product innovation performance
As I just mentioned, we are using a very key metric which is the NPI-vitality to measure the return of the investment. For example, our target for this year is that our new released product should contribute for one third of our total revenue. So this is good to reflect, if our innovations are really appreciated by the market, this percentage should increase but if the innovation is not that effective, this percentage will be lower. Therefore, this metric is used to indicate how our innovations are accepted by the market. One example is that last year due to the Covid, many of our productions were delayed and our NPI-vitality was lower than 20%. Since last Q4 when the Covid-situation is a little bit relieved, this metric has increased back to the target that we set.

Do you have certain metrics that take into account sustainability performance?
I am not sure what you mean by sustainability performance.

Sustainability performance consists of socio-economic performance, safety performance, environmental performance such as the recyclability of your product or innovation?
So I have to say with concerns to safety and environment, those are mandatory in our business. So we have a baseline, and every business should be above this baseline and target. We have those metrics on our daily dashboard and follow those mandatory procedures within GE and by following those mandatory procedures we get a better result. For example our safety, every time we start with those procedures and those topics are very simple as we are meeting them always due to the fact that is a baseline. Therefore, we are not competing on those metrics and as long as we can meet this baseline, our business is going in a healthy way.

So sustainability, safety, environment are more a baseline rather than increasing sustainability performance for example increasing the recyclability of your product?
Yes, right! We have the baseline appearing in every dashboard for example, every monthly business review we take into account the safety and environment. The guidelines from the company are really strict and therefore, we are able to meet the baseline and those metrics?

Can you give me an example of such a metric?
For example, environmental metrics depend on the business. For example, we have an imaging agency business which are contrast agencies for ultrasound devices. The development of these agencies need to meet certain targets related to water and air pollution. However, for our device business, it is mainly about those materials we are using. We have dedicated a team towards the usage of materials and they need to find vendors and the vendors need to pass certain criteria in order to use their materials.

Finally, can you share a list of metrics with me that you are currently using?
I have to ask about this. I need to have the permission to share these as we design those metrics with the expertise of LEAN coaches and business teams.

E.2 Interview Philips

Date of online interview: May 14th, 2021, 11:00 AM (CEST)
Interviewee: Global Portfolio Management/Strategic Programs – EMEA, APAC, NA, ANZ
Language: English
Before the start of the interview, an agreement was made to record the interview and to make a transcript for verification.

What is your definition of RI?
I have created some brief notes which I will use to answer some questions so I can structure my thoughts better. My idea of RI is that an innovation basically can happen anywhere in the world and in the case of RI, people are looking for innovations that are conceptualized, developed, tested and commercialized in developing markets and for emerging markets. In earlier phases, most of the innovations and developments come from developed countries but as we have progressed more and more, we have seen that more ideas are getting commercialized in developing countries. Mainly people want to initiate and implement those ideas in the market where they are developed and later we take it further to other markets based on their success as well as the need in the developed markets. That is overall my idea that it is kind of reverse due to the fact that classically it has been told that developed countries develop innovations and then it gets brought to developing countries. Right now the story is changing, because it is more both ways as we are getting a lot of ideas transferred from developing countries to developed countries.

Based on your definition, how many RI initiatives are the currently pursuing?
I am not sure what your horizon is in terms of time span, because we have been developing innovations in China and India for the last 15+ years. We have one centre in Bangalore that have been working on the software side with around 4000+ people working on software solutions and some of these are a kind of products as well. In addition, we have a centre in China that is mainly driven on product development and manufacturing. Last 10 years, we have a lot of new products coming out of India with a centre in Pune which is close to Mumbai. This centre is close to 1000 people working on different innovations and technologies. So if you ask me, I can't even tell you how many innovations has been done but what I will do is pick some examples that I have worked on.

I will talk about three products, two in the digital radiography space and one in the mobile surgery space which was done by one of my engineers and I was close associated in working with him by guiding and consulting him. One of the products was the PrimaryDiagnost which we started in 2012. This product was mainly made for emerging markets because we felt that we had good diagnostic x-ray in the high-end segments of the market but if I talk about the lower segment of the market, there was a gap. This was mainly developed by very locally, Chinese, Italian and some other players. We thought that it was good base layer because Philips had no entry in those markets and this product could provide us with a little bit of entry and it also brought us with access to good quality products. This is one innovation we started, you can imagine, an x-ray device has more than 1000 parts and therefore you have to work very closely with different teams, trying to conceptualize and design the product. In order to do so we used all kind of customer studies. So we talked with a lot hospitals in China, India, Middle-East and Asia, we collected a lot of feedback. Then we said this is a viable product to start with, and we worked with a lot with Chinese and Indian suppliers so that the product was

designed how the way we wanted and the procurement is also set up in such a way so that later on when we start shipping, we have everything in place and then we launched this product. Another part of it was that most of these innovations are done pretty quickly. If the products we are doing in developed countries have a longer cycle of realisation, usually it takes 3-4 years to launch a very complex product. Here, we have done the innovations in 15-18 to months so we have a time reduction of 50%. If we take a look at some of these products such as the DuraDiagnost, the PrimaryDiagnost of the BV Vectra, the cost have been very aggressive so we always we say that we should control the cost as these products are designed for very price sensitive customers and for them every dollar counts. Therefore, we are very prudent and pragmatic around the cost. So we had a lot of examples, in which we started, conceptualized, worked on the innovation and launched in the developing market and later we expanded the horizon to take it to the developed market.

So three examples of RIs you have worked on are the BV Vectra and which others?
Yes, so the BV Vectra is a side product of which I have worked on. PrimaryDiagnost and the DuraDiagnost are products that I have worked on as I was the product manager. So I have worked on the design, the development and the manufacturing. However, the DuraDiagnost was transferred to China as we wanted to produce it locally there and most of the suppliers are based in China.

So as I understood it correctly, these innovations are developed and launched in the emerging market and later transferred to developed markets?
Yes

What are the main reasons for pursuing RIs?
This is a very interesting question. There are a couple of points I want to highlight here. One of the main reasons, we thought of for starting innovations in emerging countries was the whole concept of doing faster execution of innovation. As I told you, we have very good innovations from developed markets but it was taking quite long and we did not have that much of bandwidth when doing innovation in developed countries. So okay, we said let's try to do innovations quickly in emerging countries. The second reason is that developing countries are places where we can localise a lot of parts. So let's say I am developing a product and I have to source the parts from developed markets, this becomes equally expensive. Slowly, we already had a lot of suppliers and manufactures in India and China from where you can source the parts and they are not that expensive. If they are sourcing it locally, you can save a lot of import duties and hassle of supply chain and what not. So that's another thing that there was a lot of localisation in these emerging markets.

Third, a lot of these entry-level innovations are related to what is the end-price point for the customer. So how can we control the end-price? It is a factor of what are your costs. Any commercial company is interested to rollout the product but at the same time make it commercially successful so they are also intended to sell the product with profit for example we want to reach a certain profitability target and also my EBITDA has to be in the right place. The fourth reason is the proximity and the know-how, in those emerging countries. So if you are operating in a certain market, a lot of knowledge is available locally and therefore, you will be able to customize your product accordingly. The last reason, is that as a company you always want to expand. In the case of Philips, we wanted to expand to small-sized hospitals. So these types of RI help us to do that. For example, if I go to a small-sized hospital with a premium product, they definitely don't have the budget or the muscle power to buy it. But if I go the

these small-sized hospitals with the Philips brand and a product that is in their region with good financial models, they are more than happy to enhance with Philips and start experiencing the products, which are innovative, have a good quality level and sometimes last longer. For example, if your product lasts 5 years instead of 10 years, your ROI is not justified as you will pay more service costs and the product might lose its functionality. So to summarize, there are five reasons: There is a faster innovation execution, localization of supplies, the possibility to control the costs and thus the price, expanding the relationship with healthcare providers and use local knowledge. Based on these five reasons, more and more innovations are developed in emerging countries

Why would you transfer those products to developed countries?
So when we started the development of these products (7-8 years ago), we reached out to these markets but we did not see much demand in those developed countries as we are very premium markets and the customers needed those premium markets. But what happened when these products got successful in emerging countries and people saw this success, they realized that they are missing on something. First, customers in developed markets never explored the innovations form the developing countries but once they saw the good success of the emerging markets, they came back. This is due to the fact that people in developed countries thought that innovations that come from developing countries might be low on quality. But that is not true. For example, in Philips, for every innovation, the same principles, same metrics, same quality control measures and same security control measures are used and we try to make sure that the product is the best and greatest. At the same time, we are trying to use supplies that are cheaper than supplies in Europe. We are also using labour from emerging countries which is cheaper than the labour in European countries. So we do get benefits of all these things and try to pass it to the customers. So I think that the initial impression also has changed. For example, when I lost some of my initial products in my portfolio, I had a lot of communication why products from India and China are not low on credibility. Because I think that some people are trying to associate products from India and China with low credibility but we are one Philips, either we operate in Europe, India, South-America or North-America as we are following the same principles.

So there are two things, one is that there was a latent demand in developed countries that was not explored. So when they saw the success, they thought, okay, let's try this opportunity. Second, a perception of quality changed over the time. People realised that the products are really robust, they are doing well and their complaint rates are low. Therefore, we have seen a lot of interest in those innovation. We have sold for example some DuraDiagnost in the United States, but we also sold in Germany, other Northern-European countries. For those countries, the adoption and the feedback was quite good because people are buying products for a price that is 50% lower than the premium product and it is doing the job. For example, maybe I need the device only for 10 examinations a day instead of 50 to 100 examinations a day thus the cheaper product might suffice. So these are the reasons for the shift of developing markets to developed.

For the developed markets, are you focused on specific segment?
Yes, definitely. So we are also to the product positioning. So we have three major segments: the premium segment with all features, we have the performance segment with limited features or slightly different platform and we have the value products for the entry-level segments such as entry-level diagnostic centres and hospitals. In addition, those value products can be used as back-up products

next to the premium product. For example, you already have a premium device as a main system but what if this system requires service, you can still perform diagnosis and different procedures. That way, a lot of countries have followed that so those RI products can be back-up products or they are used in entry-level clinics or hospitals.

The perception of products is a very important point. So you see a lot of companies move their headquarters to India and China and they also have invested heavily in manufacturing in those countries. But there are also companies such as Apple that sell products that are made in China but all of us associate Apple with premium devices and we pay 10 times more for an IPhone than we pay for a Motorola phone that provides you with equal functionalities. So important to note is that a brand is built over time, the confidence, the customer service, the loyalty etc. also matters in the perception of products. For example, Philips turns 130 years and over the years we have built trust with our large customer base all over the world. So that way, you can compromise for the way people perceive your products that are produced in for example India or Brazil.

Do you currently have any performance metrics developed and used for RI initiatives? If yes, what are the indicators/metrics that you use? Do you have a list?
We don't classify innovations to be RI and therefore, we use the same measures for all products. For example, we use the same measures for the premium segment and the entry-level segment and we are not trying to create a separate set of definitions for these entry-level segments. However, the targets can be set differently and more aggressive for entry-level innovations to have a ceiling point for pricing and costs. Despite the fact that we don't have separate measures for RIs, I will tell you which measures we use. For the financial perspective, we classify order intent which is the amount of orders you get on a monthly basis which is a standard measure. The second measure is the amount of sales that is realised from the customers. The third measure is the integral gross margin which is how much margin you make after removing some operational cost etc. The last measure we use is the EBITDA which are the Earnings Before Interest, Tax, Depreciation and Amortization. So these are the four measures that are used for all products and of course the RI products.

Another thing we take into account is cost control where we look at the factory sales price. So here the targets for RI products are more aggressive because the major cost is the build of material cost on which we have to be very prudent. Further measures are on customer satisfaction. So on customer satisfaction we measure the NPS and the call rate. The first is the Net Promoter Score (NPS) which means how many customers are really loyal. If we have a scale from 1 to 10 with 10 the highest and 1 the lowest. If a customer gives you a 9 or a 10, the customer is satisfied and will become an advocate for your product. So if we go back to the IPhone example, when you are very satisfied with your IPhone, you will tell are your friends that it is a great phone and they should also buy it. If a customer gives you a 7 or 8, you can identify passive customers but if a customer gives a grade of 1 to 6, they are becoming detractors. For example, if you have a bad experience with your IPhone, you will tell your friends that the phone is bad and they should not buy it. Next, the call rate is how many times we get a call from customers for feedback and support. For example, if someone calls about how to start the system? Then you know that you have not provided the right level of training or the training staff in a hospital has changed and the people that are trained, are not working in the hospital anymore but also calls for service and part failure. The last one that is very important within our business is the quality score. We measure this by the quality norm which are the amount of complaints you receive for a particular

system on a monthly/yearly basis. Second, we measure how good is our manufacturing, so how many times we have to do rework which is called first-pass yield: Is the innovation passing on the first go or does it require updating the system. The third measure to determine the quality is looking at the ratings and the reviews we receive of our patients and staff that are using our products. So how are we performing with respect to our product, service quality and service experience.

Are those measures part of customer satisfaction?
Yes but we have parted quality norm because we feel this is a very important parameter. If the customer is satisfied, then of course the quality norm will be high because we perceive that the product is doing well. Due to the fact that we are talking in the business-to-business space, were the products are less customer oriented but more enterprise oriented, and there are limited users. If these limited users rate this product very high, the product performance and the quality is up to the mark. That's why we keep it a little bit different and measure it more on the quality side. Finally, I want to highlight that we have a strong measurement of our security controls, both cyber security, physical security and hardware security. What we also do, is measure how many incidents happen for each product and solve those incidents as quickly as possible so we do have very strong security controls and measures.

Why are you using those specific metrics?
The metrics we have are related to the three C's we have. These three C's stand for commercial success, customer success and control success. By commercial success, I mean the financial outcomes and strategic fit. By customer success, I mean clinical outcomes by patient and staff satisfaction of hospitals. By control success, I mean highest quality and security. These are very important because we as Philips designed a quadruple aim with thus four important pillars: financial outcomes, patient outcome, patient satisfaction and staff satisfaction. These are thus the guiding principles for doing any innovation. Therefore, the chosen metrics are based on the four pillars and therefore, these are very important to deal with and stick with it. At the end of the day, everything is about customer centricity. So if the customer satisfaction, patient satisfaction and staff satisfaction is not there, the financial outcomes will not come for neither the customer and Philips.

And those metrics are used across the whole company?
Yes. So as I mentioned, within Philips, we don't differentiate whether we are developing a product for developing markets or developed markets. For us, RI is more like a process flow then a process compromise. So I will say, it is more like a logical extension of products created in developing markets, logically going in strategically fitting into developed markets. Therefore, it is not a result of quality measures, restrictions or cost restrictions.

Do you know how those metrics are developed?
Within Philips, we have a strategy team that looks at the overall Philips strategy. Over the past 130 years, We have done more than 50000 innovations and we have 100000 patents. So as a company we have been in very diverse industries such as televisions and semiconductors. Within the last 10 years, Philips want to be a healthcare technology company so that becomes our main strategy. So within the healthcare technology business, we have a guideline such as the quadruple aim and we want to become more and more customer centric which is the staff and patient experience. We also have our behaviours we want to follow. We have five Philips' behaviours that are important for all employees. Customer first is the first behaviour. The second thing is quality integrating in everything we do. The

third, is team up to win. These are the three major ones. Than we have inspire others as the fourth behaviour and I am not sure what the fifth is. Now we can combine these and based on these, we want that are financial measures and metrics cover all these principles. We thus follow those behaviours and stick to our quadruple aim. Therefore, these approaches are all top-down and all layers will work based on those behaviour and aims. Based on that, every business will define their criteria for commercial, customer and control success. The approach Philips is using is thus very structured and top-down and being populated and communicated in how Philips runs its business. That's why you see very standardized measures across all business.

So there are three main areas in which the measures are categorized?
Right, so that is what I said, we have three main areas. But we also have some softer KPI's regarding the people development for example. These are also measurable inside but they are not directly related to RI development. There are thus a lot more softer aspects for different parts of the organization but they are not important for RI measurement.

What measures, indicators or categories are becoming more relevant for in the future?
So this is a difficult question because I will not try to rate one measure over the other. Based on the three main dimensions from Philips, I would say that customer success is the most important. Hereafter, control success is the second most important and commercial success becomes third. From the perspective of Philips, we feel that is we have great performance on customer success, the commercial success will be there. For example, a happy customer will always provide more business and at the same time, we will have a more lasting relationship. This is also what Philips has been pursuing last years as we are moving away from transactional business to more relational business. So what has happened last 5 to 7 years, we want to be a partner of choice and not a transactional partner from which you buy something and go away. Therefore, customer success is the foremost thing. In addition, control success is becoming more and more important such as regulatory, quality and security topics. If we do those two things very well, our commercial success will come as well.

Which indicators or metrics are used to measure product innovation performance?
Some of the measures I have talked about fall into this category. So one of the things is: how do you really do an innovation with minimal parts and at the same time, have the least costs. So functionality wise, I am trying to replicate 90 – 95% of the functionality of a premium system but how do I conceptually make a product with this functionality but at a reduce cost. So cost optimization is one of the key factors in the design of innovations. We need to assure, we don't have extra parts or materials so the redundancy is to a level that we meet all criteria but not overdesign it too much. Overdesign can cause an increase in costs. The second, I would say, the product innovations should be simple to install and in the least possible time. I say this due to the fact that a lot of these costs goes to installing the system. For example, if a product can be installed within a single day in comparison to a premium product that requires 5-days installation, a lot of costs can be saved. Installation and innovation is very important. The third part is the customer training. So I take the same example from the IPhone, if there is a simple guide within the box, you can directly use the phone. So what we have done within Philips, we need to have a simple product design-wise and training-wise. Therefore, we need to provide our products with self-learning material. We also provide a lot of material in a CD, a USB-stick or DVD-drive so that the customer can use and start learning the system by themselves. Furthermore, it is not as simple as a phone because it is a x-ray device but of course you can do on your own. Therefore, training

is also something of the innovation part of product development. So we have been focusing a lot on innovations from the product side and we measure if the product is optimally designed, simple to use and easy to install. All those things help us to control our cost and keep the price at an RIght level.

Which indicators or metrics are used to measure sustainability performance?
Philips is a very environmental company. We have an environment, social and government (ESG) policy, so we have been very conscious and strict measures to our innovations and product designs. So we something that is known as equal design which consists of eight basic principles. I don't remember them by heart but I will give some examples. First, we measure how much of the material we use as packaging material can be reused. So what we have done is, we have either used a wooden or cardboard material that can be reused. Furthermore, we tried to ensure that these packaging boxes can be used for reshipment. The second part is that we have a very strict policy on the kind of material we use as batteries. We try to not use any hazardous material when designing a system or product. A third thing is that we try to minimize the weight of the system, so that fuel used to transport our systems, will be lowered and the carbon footprint gets minimized. However, these measures and principles are not new to Philips as we have been using them for many years. When I first worked on products that I have developed and designed 10 years ago, the same principles were used, they only got a little bit more tight and stricter. In addition, what we have been doing is that we try to reuse a lot of components and refurbish. These parts can be used as spare parts for a lot of systems and we can tell the customer that we have used recyclable parts. So if we are really determined to minimize environmental impact for example we have been very conscious on work related travels to reduce the carbon footprint. So we are really determined to meet our principles and follow the ESG policy. Furthermore, our CEO is a big advocate of sustainable development and Philips is committed to become one of the leading companies on the behalf of sustainability.

Do you also have any measures regarding social performance?
We have a sustainability group that takes cares of the definition of the principles. They measure those principles on a regular basis such as the how many parts of the products are recycled. Then there is a wider Philips initiative on sustainability that focuses on reducing the carbon footprint by the employees etc. Another example is that most Philips offices and factories are becoming carbon neutral. There are many initiatives that are currently running and we do have a dedicated group with senior officials who take care of these initiatives.

Could send you me a list with specific KPI's based on the innovations you made?
We kind of discussed a lot of it already. What kind of KPI's are you looking for?

I am looking for really detailed and specific KPI's that use in daily management
So let me think over it and you can drop me a note what exactly you are looking for. I can then look for the right information. So think over it and if you know what you are exactly looking for or if you need more information on a specific topic, you can contact me.

After the interview, additional questions were asked via e-mail.

Do you have any measures regarding the efficiency of product innovation?
Yes, we do have innovation roadmaps and this includes many new/incremental ideas. These ideas and filtered based on strategic fit, market/customer attractiveness and financial evaluations (business case). We do have Strategic Plan of records (3 year forward looking) as one key indicator of innovation

pipelines. In general we start with many ideas and narrow down to few good ideas only. The portfolio management team and management is heavily involved in this screening process.

Sustainability also consists of economic and social aspects. Do you have any measures aimed at those aspects?
Yes, we do have EcoDesign principles aimed to make our products environment friendly. There are elements related to minimum system weight, use of zero hazardous material, bio-degradable packaging, recyclable parts etc. Philips is committed to reduce carbon foot-print to maximum possible level.

E.3 Interview Roche

Date of online interview: May 18th, 2021, 09:00 AM (CEST)
Interviewee: International Product Manager
Language: English
Before the start of the interview, an agreement was made to record the interview and to make a transcript for verification.

Do you currently have any performance metrics developed and used for healthcare initiatives? If yes, what are the indicators/metrics that you use? Do you have a list?
When you are talking about indicators or metrics, on my side we mainly use business indicators to see how our products are fitting the customer needs. There are two predominant metrics that we use. That are the number of installations, number of active instruments and the number of ordering. Those metrics are on how much the solution, the innovation or the solution is placed in the market. The second metrics are on the sales side, so what are the revenue, the operating profit, the gross profit and the typical financial indices that are related to the product. Of course, there are many other indicators for example the complaints rate so how many complaints there are relative to the number of instalments of the device. Another example is the acceptance rate which is usually measured during the campaign.

Do you also margins, ROE, ROS?
Yes, we start a development or a project, we calculate the net present value (NPV), the internal rate of return (IRR) or the payback year for example. We do this to evaluate the development of the product. Furthermore we do the cumulative sales, we do a projector for the gross profit and operating costs.

So those are the main financial performance metrics that are currently used?
From a franchise perspective, I would say yes. Of course, our finance team do a more detailed analysis but for us it is important to know that those numbers are good.

Why are you using those specific measures?
From a financial perspective, those are common languages that are used. These are understandable measures and everybody will understand those measures like for example, the discount rate, the NPV or the IRR. Therefore, it is easy to spread those numbers around the organisation. Keeping in mind that we are a global organisation, we are talking to different regions and nations that all have their own business models and different organisational tools.

Are those metrics used across the whole company?
Yes, it is guided by the finance team within the organisation. We have a business case model to analyse and evaluate processes. When you talk about different components, we have different subsidiaries and for those different subsidiaries, yes we have the same measures and metrics.

How are these metrics developed and on which method are those metrics based?
So the metrics are developed by the financial team and metrics such as the NPV is more and less the same all over the financial world and the same holds for the gross profit and other financial numbers as they are pure calculations.

Are there any categories within the company that are used such as for example customer satisfaction?
Yes, absolutely. So as I mentioned, we measure the number of instruments that are placed and from an instruments placement there are some subcategories such as the number of active instruments, the number of ordering and the numbers of replaced instruments. Based on these numbers, you will know the installed base per region and per country and they affiliate level per customers and so there are different layers. In addition, you mentioned the support side so the service and support. You should analyse what are the typical costs that are inside the R&D and the launch preparation. On that side, we have the service cost and in the service cost, there are many factors that are including the number of complaints per installed base which we call the complaint rate. So we will know that for each region, we install devices, we have a certain amount of complaints. For example, if I have 100 installed devices and a complaint rate of 0.05, we have 5 complaints. From there, we set different targets so for example for a specific device that is on the market for 5 years, the amount of complaints has to be lower than this number and on this number, the KPI is built. Customer satisfaction as you mentioned is more on the marketing side and we do a customer survey to collect feedback from the customer both quantitatively and qualitatively. Furthermore, in relation to the service and support, there has been a global survey send out every year and based on these survey we get feedback from the customer how they are experiencing Roche. So we are using those surveys on the marketing side and the service side.

Do you have certain metrics that take into account your partnerships with the hospitals?
Those metrics are more focused on the local side because from the global level side, the typical survey that we are sending out, is sent out randomly. Furthermore, from a global side we do not have that frequent contact with our partnerships. So from my side, we do not have so much direct contact. I mainly have contact with the key opinion leader and sometimes I am visiting customer. When I visit those customers, I will always ask: what is your opinion with Roche. Those customers are either happy or they are problematic and we need to solve some problems. At a local level, we have a customer relationship management tool and this is connected to our ERP software. Al the complaints data are stored there. So at a global level, this will be too much data to analyse but at a local level, we have our own visibility and we can understand how the interaction with the customer is going. Besides, we have the business metrics that assess how much interaction there is with the customers. For example, I went to a certain hospital and I talk with the general managers and the feedback from those people is stored within the company. At a local level, there is a clear picture of how the relationship with this customer is performing, to create a stronger partnership. The most important information on those customers, is raised to a global level and they arrive at my desk. So if there is need to improve a certain device or if there is feedback on something that is going well, we need to keep it and maintain it.

Are the metrics categorized into certain aspects?
In relation to performance, we have as I mentioned the business performance and the financial performance. Furthermore, we have some clinical studies to determine the medical performance of our instruments and what they are providing to the healthcare institutions. We also have health economics studies in order to determine the cost effectiveness of a solution. We also have some measures on market access. In addition, we have a pricing performance analysis which consists of an analyses of our average selling price and the price fluctuation in the market. There is also the typical

marketing analysis in which the competitors are analysed. In this analyses, we try to identify what the competitors are doing, how they are performing, what we are doing well and how we can learn from the competitors. I would say, business, financial, service, medical performance, market access, economics, pricing and competitor's analysis are the main categories that we use in today life cycle management of a product.

Are there KPI's within the organisation for other internal categories such as the learning perspective and the organisational performance?
yes we have those type of measures. However, these are mainly on the human resources (HR) side and therefore, I did not mention them. Of course, we have to take into account the training we have for new employees and for this training we have certain targets. Furthermore, it depends on the different roles within the company. So somewhere in the HR, different KPI's will be maintained for the knowledge level within the company and this is thus for the internal population of the company. For the external population (customers), we are also organized on learning by providing different learning platforms and tools.

What measures, indicators or categories, do you think are more relevant in the future?
I think we are more going on the digitalisation, so the customer will have more and faster contact with the company than in the past because the access of to the information will be more spread and the data analysis will be more complete. From our side or from customer side, there will be much more relationship than in the past. This is thanks due to the digitalisation of course.

So metrics that take into account customer relationships such as complaint rate will become more important ?
Yes definitely and more for example predicted maintenance as there will be much more data available to help the customer relationships. But also from the medical side, we can provide the customer with much more information on how they are performing and together we can improve the medical outcome. Those are eventually the big goals that we have in mind today.

Do you have examples of healthcare initiatives within Roche that are developed for emerging countries?
Sure, we have multiple initiatives going with emerging markets from different sides such as the diagnostics. For example, we have been developing an application for HIV patients in Africa. I think that was a pretty interesting project and you can find information on this project on Google. Of course, there is quite a focus on developing markets because when you are talking about developing markets, you are talking about Latin-America (Brazil). For us, these are key markets, that are growing very fast. India as well, there are some area in which the current market is very interesting for us. It has been historically an interesting market.

What are the reasons that you are interested in those markets?
Market size and specifically for certain types of products. These products are combining simplicity and cost effectiveness.

Do you have any examples of these type of products?
I don't have those products in my portfolio but I have an example which is called the 9180 Electrolyte Analyzer. This is an electrolyte diagnostic device that is used to screen electrolytes. The main market is the emerging market.

The main market is the emerging country, is Roche planning to sell those initiatives in developed countries?
For this point of time, Roche will keep those products in the emerging market. The reason is because this product was developed for mature markets and it results obsolete Europe for example. the samples throughput and the test panel is fitting with the needs of emerging markets.

What are thus the reasons for not transferring this product to developed markets?
It is mainly market needs.

So as I understood it correctly, Roche focuses on producing products for emerging markets due to its market size but due to different market needs, those products cannot be sold in Europe for example?
I would say rephrase the focus a bit. We are focusing mainly on Europe, US and China as a strategic approach. Especially US and China have the biggest potential in terms of strategic approach. So when you think about the development of a new product, you keep these as one of the factors the factors that can help you to get the funding for the new product. Besides that, there are also initiatives for developing countries because we have a sustainability part of the company that is investing their resources to help the local and global communities. In that case, the HIV applications was fully developed for the African region. Due to the fact that in our world, there are no difficulties in infrastructure, the developed market have a proper healthcare situation.

Do you consider RI as a potential strategic approach for Roche? Can you explain your answer?
Probably on the digital side, we noticed that our initiative on emerging markets, can be spread later in developed markets. I am thinking for example, on the medical condition analysis or the patient user platform, it is quite widely used in Brazil or in Latin-America than in comparison to Europe. Of course, there is the GDPR in Europe, for example, that is creating limitation. But I feel that the adaption and use of the digital solution in the emerging market can be in some cases be much disruptive than in developed countries and some things can be learnt from emerging markets. In my specific field, I do not have any specific example of RIs and I think transferring innovations is difficult but for the digital side, it would be possible.

What metrics are used to measure product innovation performance?
So we have early Innovation and research team spread throughout the R&D organisation. We are also fostering the new idea generation internally and also externally. For example, we partner in laboratories for start-up sand accelerator programs for start-ups to understand what could be the next disrupting innovation. So definitely, we have also internal initiatives like the R&D days in which the most innovative aspects are presented and awarded. We try to scout continuously the market, to create patents. In the life science sectors Roche is systematically ranked as one of the companies registering more patents per year. In terms of R&D investment, we are usually on the top side. So we invest one of the highest ratio of sales/R&D investments the healthcare sector.

So you keep track of the amount of patents, the amount of investments for R&D?
Yes, I think those are interesting for the development teams.

What metrics are used to measure the sustainability performance?
I think you can find a lot of different KPI's are placed on our website. We have different multiple initiatives in the area of innovation, we have great working-life balance, we have partnerships with institutions, patients, communicates and environmental groups. So there are multiple ways that Roche tries to influence the society. So we are also continuously investing and enlarging the topic of

sustainability. So inside the organisation, those things are heavily spread. For every development of a process, multiple analysis are performed to control the CO2 emission or prevent for hazard compound use. We always try to stay on the safe frequently above the regulation.. In the production side, the consumption of energy is taken into account. Furthermore, every employee receives a letter with an analysis of their CO2 consumption related to performed travels. So for example, you need to rethink when you plan take a plane.

On a daily basis, sustainability is discussed within Roche both externally for example does our products help the community but also internally for example certain guidelines for every employee?
Yes you can feel it, for example our buildings do not have air conditioning so when US colleagues are here, they say: you are crazy. However, we say that we do not want to harm the environment with the pollution.

Thanks to the interview, different KPIs on five categories were found on the website of Roche. Those KPI's are based on the sustainable growth that Roche desires. The five areas that Roche differentiate on their website are innovating for patients, providing a great workplace, being a trustworthy partner, protecting the environment and delivering continued growth (Roche, 2021). Furthermore, they identify Safety, Security, Health and Environment (SHE) goals which are based on the SDGs that are mentioned in section 4.4 (Roche, 2020)

E.4 Interview Siemens

Date of online interview: June 4th, 2021, 11:30 AM (CEST)
Interviewee: Product manager
Language: English
Before the start of the interview, an agreement was made to record the interview and to make a transcript for verification.

What is your definition of RI?
So as we discussed in the introduction of today already. RI is not a term that is consciously and precisely used in the organisation in which I am familiar with. This term was mainly introduced by you to me so that's why I can somehow refer to concepts of frugal innovation in the context of the definition of Clayton Christensen in which he explains frugal innovation in the context of disruptive innovation. Therefore, I can relate RI as a subset or sub-element of these ideas. From the understanding we developed last time, RI is that you have a purpose A to innovate in a product segment or category and finally, you are surprisingly or by intention reusing the product offering independently in a different context and sell it to a different target customer or a different target market. Here I use the example that was mind-opening to me when I learned about RI. There was an Electro Cardiograph from a competitor that has been developed, innovated and sold in India and for India. Hereafter, it became available for the rest of the world and this was quite successful as it was perfectly hitting the head of the nail. It was planned to be a rather high-end product offering for India, it was a perfect match for the efficiency segment of cardiologist practices in US as it was at a target price of roughly 1000 dollars. It became so quite affordable for those specialties that require valuable products rather than high-end products that cost roughly 20000 dollars.

Do you believe that frugal innovation is the base of RI?
This is an interesting question. I would not use the word base to describe the relation between frugal innovation and RI. However, I would say this could be the beginning or the seed of RI. So let's say, disruptive innovations or frugal innovations, it is not precise to put them in the same sentence but frugal innovations often have a disruptive element. The more disruptive you are with your innovation, the more jobs and more markets are created. This means that by definition those kind of innovations are not only targeted to one single market but where ever they are targeted to, they can create business opportunities, markets and customer needs. So it is not a base of RI but it the trigger of RI. So by intention those kind of innovations can be reused to one target market but to many target markets. I would see RI as a kind of subset of disruptive innovations. They do not need to be disruptive but by intention they have the potential to be reused in at least two different directions or contexts. You start small and you think big and you grow in another business opportunity that you are not aware of at the very beginning?

Do you have any examples of initiatives of RI?
Not at the moment. The examples that we talked about in the past such as the SomaTom Smile project. This project had the potential at that time to become a product that was sold across the world. The product itself was initially developed in China and for China but it was not purely designed in China. Unfortunately, the rest of the world was at that time not ready to receive those products and anything that came with the label 'made in China' was accompanied with the perception of an emerging market product with a lower product value. At the moment, there is no project that I would see as RI. Here I can only speak for a part of the organisation as I am not able to foresee the whole portfolio and product

initiatives. There are corporate research activities that are driven on a local basis. This is why that I am totally convinced on the frugal innovation perspective. It is difficult to drive projects from a global headquarter. You should allow to include ideas, in concepts, approaches and products types that come from local corporate research activities in your innovation road map. There are very nice ideas and innovations from India that show in comparison to a global need level the pocket-size is a completely different one. For example, a couple of years ago, our research group in India came up with a proposal to connect our IPhone with a very special microscopic camera that could replace expensive microscope. If you link your IPhone with a little bit of hardware, you can replace the functionality of the microscope with a more cheaper device. However, I am not sure if this products is already successful because maybe it is still in the concept phase. It could also be that another small start-up made this product before we can.

What are the main reasons for pursuing frugal innovation and RI?
As already mentioned, the value of a rather high-end product or rather expensive product for a developed market. It is not easy to sell this product in an emerging market and the product segments below. For example, you cannot simply remove one wheel of our car to make it cheaper. Therefore, some components always need to be in so if you really want to revolutionize and make a product for the low-end segment of the market and make this product profitable. You need to rethink your system and product concepts in a way that for example has the outcome that it is a car with four wheels. So in the context of resources and pocket-sizes, they are smaller compared to developed market. Therefore, it is much easier to find this kind of compromise of good-enough product concepts within emerging markets. I do not have a lot of details available right now but if you think about the generator of a x-ray source, do we always need 200 kilowatt to equip a computer tomography system? Why can't it be the fourth of it if the diagnostics image quality is remaining the same? So if you think about an American customer, they are used to a certain amount of specs. So if the kilowatts is the most important specification of the device, so the more I have, the more powerful the machine is. Therefore, you are able to scan more heavy patients. Such a low-end customer in America would never come up with an idea to limit the generator power. But if you look to reference customer target group within the emerging market, those customers would much faster and much easier give up on those specifications values. Thus those customers are more easy to give up on the amount of kilowatts as they trust the company when they say that the same image quality can be reached with less kilowatts. They can then save a lot of budget, effort on manufacturing side but also on the product price side. These are bottom-up innovations and can only be triggered by emerging country customers and not by developed country customers. That's why MNCs have to go to these emerging markets and talk to customers because they will come up with market requirement specifications of an ECG such as the BRIVO that allows for some limitations. You need to have limitations to make the difference and say look guys, this is still considered to be a valuable ECG or CT. It is compromised in some way but the compromises will not bother you or limit you.

Why can those products be transferred back?
If you can convince the American low-end customer by just the fact that the image quality output is similar to the high-end product and ask them if this quality is sufficient to them?

So it is about similar demands or needs within specific segments of the developed market?
Yes, I think it is that way. So for example, when you are on university, you don't have a lot of money available to buy a car. So you will buy a cheap car but it does the job for you because it transports you from one place to another place. This is similar for the healthcare products. So if you have something to offer that is still from a big brand, it does the job, it is not a bad product, it is safe for the patients,

it is very efficient and productive, it comes with a very simplistic user interface than you can convince the customer to buy this product. However, you need to offer both the high-end product and the low-end product and at the end it is the choice of the customer.
Do you currently have any performance metrics in use for your product portfolio with respect to RI?
With respect to RI, there is no specific metric in place that is used and valued. There are some weak reasons why we do not have them but no good reasons not to have it. It is just that most of the product success is mainly measured by financial KPIs and those are priority number one. So market penetration, market share, market share change, respective contract rate. When it is about service, this is also about financial KPIs so customer realized price, service contract price, the respective take rate, win-loss comparisons. At the end, we also take into account profitability rates such as gross margin and profit margin.

Why are you using those specific metrics?
We are using those metrics due to the fact that we are using them across the whole organisation. The company is controlled by business performance controllers and financial performance controllers. They break everything down to their KPIs and they judge everything based on that. I think there are no big differences among the big companies such as GE, Philips, Canon, United Imaging and Siemens. I think it is the easiest way to control your business. Is the most reliable and sustainable way to control your business? Maybe not. Would it be more sustainable and reliable to also include factors that I mentioned before such as how disruptive is this product and how sustainable is this product. It would be very helpful in a rectangular value system to monitor these kind of KPIs. You could see much more on how nicely does it work. The big issue with that usually arise with those RI products is that they can be cannibalizing. So for example with the ECG from GE. This product can be sold for 1000 dollar in India and 2000 dollar in the United States. You ignore the higher willingness to pay and the higher liquidity in the United States market. The product can be more expensive and that is why usually the United States margin will become bigger and you can even raise the price higher than 2000 dollar. In such a way, the revenue and the profitability will increase. However, you have to take in mind the cannibalization of other products that you could sell in this market. From a customer perspective, it would be more fair to offer the best product to the customer. Even the general practitioner in the United States would get much more ECG for the 2500 dollar. If we would sell him the developed market product for 3500 dollar. From a company perspective, I would expect you would go for the developed market product instead of the emerging market product to avoid cannibalization of your upper portfolio. This is something from a global economic perspective not the smartest way but from a financial KPI controller perspective this is the easiest way. You do not need to fear that much cannibalization so you would avoid offering the Indian ECG to the United States to separate those markets. I am happy to learn how to do it better. What company is mature enough to see it much more holistically from a global scale perspective. So this is both an ecological and an economical aspect. I would love to see these kind of metrics that would help us to understand the business KPIs from a much higher level. At the moment, our shareholders have a different look on our business and therefore, it is difficult to convince financial experts.

So you already mentioned a lot of financial metrics, do you have other categories for your metrics for example customer metrics?
What do you mean by customer metrics?

For example NPS?
Yes, so I think the NPS is used on the service side. On the regular base, we do customer satisfaction surveys in which we measure the customer satisfaction. In addition, we have the utilization analysis to

do understand in what market which product is used and to what extent. So this also consists of the clinical indication profile so how many heart scans, abdominal scans and cardiac scans. This helps us to understand the target institute and the target customer profiles. So our regional sales organization can tell where to sell the right product to the right customer. However, these are less important than the financial KPIs.

Do you have other categories?
No actually not.

Do you have any metrics for product innovation performance and sustainability performance?
I would love to see examples where product sustainability and innovation sustainability can help us to see our portfolio management on a much larger scale but actually I am definitely aware that it is been done. Neither on a modality business perspective nor on a global perspective. I would love to learn more how this could be done and what the value could be of those metrics.

What measures, indicators, metrics or categories do you think are relevant in the future?
Let's use some of the examples I am convinced of and I can use a metaphor to explain it. For example you have the flipped academy which was invented by a Nobel Prize winner who was teaching in Stanford. You know from your current practice that universities work by a certain teaching plan. Usually, you go to a lesson from whatever else and you listen to a teacher. This teacher is not a good one. He might be a specialist in his research area but he is a bad teacher. What you suffer by that is not yet clear, some of the concepts that you need for your later career have not been properly transferred to you. The second part of the lessons are the tutorial were you sit in a classroom with other students. The inventor of the flipped academy is that you have to centralize the lessons in a way that only the best teachers, teach a certain course in an efficient way. You have much more time for the tutorial sessions to do the practical stuff instead of wasting time in the lecture rooms and you learn by practice. So if you ask me, what is the biggest innovation or the most relevant metric. I think that is something that can be used in a digital environment and a decentralized way. This is a trend what we are now observing and I have an example in mind. So if you have a radiologist that examines radio images in India. Usually, there is a radiologist that started that business because there was a need for radiologists in an area. The issue is now that this business is growing and he needs an additional radiologist so he has more time to focus on both the business and making scans. However, this takes additional money and you need 40 scans to justify the salary of this additional radiologist. Now coming back to your question and I took a long journey to come to the answer. What if you can hire a radiologist that is not on site but you can send your pictures to, you can save a lot of money. This becomes available due to digitalization and therefore, businesses become more decentralized and everything will become more sustainable and reliable. This digital transformation is a very big revolution. So I think what will change in the future is that there will be more imaging offices and there will be more diagnostic imaging businesses. Therefore, you do not need any radiologist on site. Everything can be done online which is the very big trend. To answer your questions finally: this is a much more sustainable way of operating the equipment. The second point goes back to the interview that you triggered, it is about measuring the sustainability of product solutions. This will revolutionize the portfolio management of medical imaging but worldwide. What can we really learn from a good enough or RI. Where can we use those good-enough concepts and service concepts to deal in a more sustainable, reliable, ecological and economical way with our resources that are limited on a global scale. I am not sure whether this answered your question. I would love to have these kind of metrics introduced but I think it will be difficult for some of these industries as they may not want to use these metrics without pressure from outside such as governments and authorities.

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