Copenhagen Business School

MSc Accounting, Strategy, and Control

Master's Thesis

CASCO1000E

Value-Enabled Strategy: Implications of Value-Based Healthcare Model for Competitive Strategies of Diagnostic Imaging Companies

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Number of standard pages: 74
Number of characters: 199,014
Hand–in date: May 15, 2018

2018

Value-Enabled Strategy

IMPLICATIONS OF VALUE-BASED HEALTHCARE MODEL FOR THE BUSINESS STRATEGIES OF DIAGNOSTIC IMAGING COMPANIES

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Abstract

This paper covers the issue of an ongoing transformation of healthcare from the value-based to value-based model. Value-based healthcare is a framework primarily developed by Michael Porter and Elizabeth Teisberg in their 2006 book "Redefining Healhtcare: Creating Value-based Competition on Results". The main premise of the book is that the healthcare delivery should center around the patients and focus on the maximization of their outcomes relative to costs.

Since 2006, value-based healthcare gained increasing interest of policymakers and businesses. Despite its popularity and huge potential transformative effect on the whole healthcare delivery value chain, studies evaluating its impacts for business engaged in healthcare are largely missing. This paper aims to address that knowledge gap by focusing on the evaluation of value-based healthcare implications for the competitive strategies of the diagnostic imaging firms.

The starting premise is that current volume-based healthcare disincentivizes adoption of other strategies besides the cost-leadership. The second premise is that value-based healthcare has a potential to negate this effect and allow diagnostic imaging firms to utilize other strategies. These premises are tested by the means of the game-tehoric modeling, and analysis of the firms themselves. Specifically, the paper focuses on how the value-based healthcare is translated from a theory to direct outcomes for the firms. It was identified that the main link between the value-based healthcare and diagnostic imaging companies is the procurement process. For this reason, the paper studies difference between traditional procurement based on lowest price criterion and the value-based procurement based on price/quality ratio.

Finally, both procurement methods are evaluated in terms of their outcomes for the competitive strategies of the diagnostic imaging firms. It is concluded that the traditional procurement indeed incentivizes adoption of cost-leadership strategy and that the value-based procurement allows for the successful use of multiple strategies.

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1 Introduction

1.1 Background

Despite its relatively straightforward objective of maximizing people's life in health, healthcare is often at the center of criticism by both the public and politicians. At the core of the dissatisfaction lies high cost relative to the quality of care delivered. Healthcare expenditure in developed countries is truly staggering with the average figure for OECD member states at 9% of their respective GDPs (OECD, 2018). Despite the increasingly constrained budgets of many developed economies, the sheer volume healthcare expenditure indicates (increasing) importance of a well-functioning health systems.

Arguably, the absolute cost of healthcare is currently not the dominating issue of the current agenda. Exorbitant growth of healthcare spend – largely defining previous decades – has to a large extent been addressed with the introduction of the diagnosis related groups system (DRG). Despite the differences in the implementation into the payment and performance measurement systems of individual countries, DRG as a dominant feature of modern health systems mostly delivered on the promise of an increased efficiency, transparency and reduction in the patient's hospitalization time[1] (Mihailovic, et al., 2016, p. 6). Notwithstanding these benefits, DRG failed to resolve the problem of care quality.

Quality of care and patient experience is currently gaining increased attention. Despite many previous efforts, improving quality level and consistency in healthcare delivery proves to be quite challenging. While the default solution to quality issues is usually increased funding, direct causal relationship between quality of healthcare and cost fails to be conclusively proven (Hussey, et al., 2013). The extreme inconsistency in correlation between inputs (financing) and outputs (outcomes for patients) indicates a problem in the functioning of the overall system.

The important thing to understand about healthcare is its immense complexity. Compared with other industries, healthcare has a unique organization defined by an extreme misalignment of the powers, roles and interests of its primary actors. For example, in the context of the European health systems, government often takes a role

[1] average length of stay (LOS)

of payer, provider, regulator and beneficiary at the same time. Such centralization and concentration of power interferes with the natural roles of:

a) Patients as the ultimate consumers and payers, and;
b) Healthcare organizations as the ultimate providers of the services

This means that the market forces that would have otherwise aligned the interests of suppliers (healthcare organizations) and consumers (patients) are severely reduced. Without the presence of natural coordination of markets, diverging interests of healthcare actors must be aligned through artificial mechanisms – primarily reimbursement based on certain performance measures. Up to this point, reimbursement was primarily tied to the rendering of a specific procedures (fee for service) or episodes of care (bundled payment). Both systems failed to effectively align interests of the main actors within healthcare.

In 2006, Michael Porter and Elizabeth Teisberg introduced ambitious new framework, which aims to resolve problems of interest alignment, quality, and cost, by putting patient back at the center of healthcare and promoting competition in the industry. The framework, now commonly referred to as Value-based healthcare (VBHC), is gaining widespread interest and its elements are currently being evaluated or implemented by several countries.

At the core of the VBHC lies the idea that the center of attention should shift from the partial goals such as cost containment or quality to the value provided to the patients. The fundamental concept of value is defined by Porter and Teisberg as *"health outcome per dollar of cost expended"* (Porter & Teisberg, 2006, p. 4). Despite the simplicity of its core idea, implementation of the VBHC will require a complete overhaul of the way care is organized, delivered, and financed.

From the perspective of providers, the most challenging part of the VBHC implementation will be the change in the reimbursement. Gradual departure from the fee for service model means that providers' revenues will not be directly reflecting the volume of the services rendered. Since nominal productivity will no longer be rewarded, providers will have to redefine their value chain to cater to patient's needs better. The way to maximize profitability under VBHC will therefore require delivery of a quality service (as relating to patient) and cost effectiveness, rather than maximization of number of reimbursed services – some of which may bring little value to the patient.

Increasing usage of value-based reimbursement, ceteris paribus, will result in a significant transfer of risk to the providers, who are currently not equipped to deal with

it. As a direct result of efforts to provide universal healthcare[2], followed by periods of cost-containment efforts, health systems are conditioned towards high-volume low-cost healthcare delivery with inconsistent quality and short-term focus. This has been translated into the relationships with the medical device suppliers, the contracts with which are often focused on utilization levels, uptime, examination volumes and return on investment. With volumes becoming less relevant and sources of revenues changing, care providers may remain fully exposed to the risks inherently tied to the VBHC. The way to avoid this is to offload some of the risks on the suppliers of health technologies, through changes in the contracting and procurement practices.

1.2 Problem Analysis

The medical technology market is facing a big change resulting from the growing acceptance and adaptation of the Value-Based healthcare framework. At its core is the idea to shift focus back to the patients and to focus on the maximization of value, which Porter and Teisberg (2006) define as *"health outcome per dollar of cost expended"* (p. 4). What this means for the medical technology firms is that the factors determinant of the success in this market are changing along with the requirements of the customers – healthcare providers.

Transition from volume-based to value-base healthcare has potentially disruptive effect on the conventional value propositions and business models of medtech companies. Changes in the reimbursement models will ultimately translate to the process of procurement, meaning that the value propositions of medical devices with high productivity in terms of examination count or high reliability will be of decreasing importance. Instead companies able to offer innovative partnerships, services maximizing patient value, or reduction of provider's risk are the ones to benefit from the transformation.

1.3 Research Objectives

The ultimate objective of this thesis is to examine the implications of the VBHC on the strategic landscape within the sub-segment of health technology[3] industry - diagnostic imaging. Market with diagnostic imaging is currently dominated with three firms – Philips, Siemens and General Electric (GE), who are pushed by means of conventional

[2] Which necessarily requires significant financial and personal resources
[3] alternatively medical technology

cost-oriented healthcare to compete primarily on the price of their products. The problem is that pure price competition restricts companies' strategic options to minimization of production costs, which adversely affects all healthcare stakeholders and decreases profitability of the industry.

The objective of the analysis performed in the later chapters of this paper is to examine:
a) whether the diagnostic imaging market defined by buyers' sole orientation on price really restricts range of competitive strategies to that of the cost leadership, and

b) whether the introduction of value component into the procurement practices creates conditions where manufacturers of diagnostic imaging equipment can achieve competitive advantage with strategy other than that of cost leadership.

Thesis first defines materialization of the VBHC in the health systems and translates it into concrete outcomes for health technology companies (i.e. procurement). Subsequently it performs analysis of the current strategies and juxtaposes them with the altering landscape of the industry and its broader environment. Finally, it evaluates viability of the Porter's generic strategies in price-based procurement and value-based procurement, through game-theoric simulation.

1.4 Research Question

What are the implications of value-based healthcare model for the strategic diversity within the diagnostic imaging market?

1.5 Significance

Business contribution

This thesis represents an early assessment of the impact of new healthcare framework on the business strategy of a major health technology company. While the existence of the VBHC is widely acknowledged by medtech companies, their interest rarely translates into actual strategies. Instead, companies approach the issue with a certain level of caution and often acknowledge VBHC as an innovation within the context of a "traditional" healthcare. It is understandable that executives are reluctant to make big strategic pivots in light of great uncertainty, but the potential benefits of early adoption of Value-Based Strategy is immense, considering the $340 billion size of the medtech market. Ideally, this thesis will illustrate the true disruptive scale and urgency of VBHC and present a contribution to professional discourse on the matter.

Broader contribution

Despite a rather strict focus on the business practice, the significance of the analyses performed throughout this work extends beyond the narrow field of strategy formulation for medtech sector. The analysis of the impact of VBCH on the reimbursement and procurement practices performed in the following chapters can benefit a broader range of stakeholders including policymakers, healthcare providers and medical professionals. Unlike academics, these groups may appreciate a pragmatic view of VBHC described in terms of concrete actions that are currently shaping the reality of healthcare.

The significance of the project is further magnified by the fact, that the idea of value-based procurement can easily be applied to other sectors such as public construction, defense and education. In this regard the project may serve as a case study illustrating impacts of value-based framework on the broader business environment.

Academic contribution

Finally, this case represents a unique chance to study dynamics of disruption of a vital yet complex, volatile and tightly-regulated industry. Connected with it is the rise of new business models and formulation of unprecedented strategies. As such this work provides contribution to the discipline of strategic management.

This study responds to the initial impulse set by the publication of Porter's and Teisberg's original work on VBHC by focusing on the issue of strategic implications for healthcare suppliers, which despite being outlined in the Redefining Healthcare, was so far covered only marginally. As such this study represents a continuation of a research covering the evolution of VBHC.

2 Literature review

In this section I will define the positioning of this thesis relative to the existing literature related to the issues of strategic management, value-based healthcare, public procurement and healthcare reimbursement. Sources reviewed hereafter were used as guide in the delineation of the problem area and some form a basis for the theoretical framework of the project. Literature review is loosely designed as a *systematic review* with the sections covering the sources pertaining to the context, intervention, mechanisms and outcomes of the studied phenomena (Bryman & Bell, 2011).

2.1 Context – Strategic management

2.1.1 Emergence of the discipline

As described in the introductory section, the main field of inquiry in this project is the issue of strategy (re)formulation in a corporation facing a changing business environment. The key concepts are therefore corporation and strategy. According to Jofre (2011) "*from the perspective of theory and practice, strategy is directly associated with the management of the business or corporate organizations*" (p. 49). Focus on the strategy in the business context thus clearly situates this research into the field of strategic management. Due to the extremely complex nature of the strategic management literature, it is infeasible to perform all-encompassing "state of the art" (Thomas, 1984). Nevertheless, the following paragraphs serve to outline the history of the field and outline links to this research.

Origin of the *strategic management* as a discipline is contested. Mason (1986) attributed development of the term to Ansoff, who is often considered a father of the discipline (Nakamura, 2007), (Anon., 2002), (Hindle, 2008). Ansoff indeed published influential books "From strategic planning to strategic management" (Ansoff, et al., 1976) and "Strategic Management" (Ansoff, 1979) both of which explicitly use the term strategic management in their titles. Nevertheless, Lyles (1990) situates origin of the term into 1977, due to an argument that *strategic management* has only been precisely delineated and defined on the Pittsburgh Conference taking place in that year.

The conference, originally held to define new paradigm for *business policy*, started with the renaming of *business policy* to *strategic management* (Lyles, 1990). The renaming took place as a result of efforts to consolidate research areas in the field. Inclusion of *policy* has been found incompatible with the desired direction of the strategic management as it represented an "*…antithesis of* [academics'] *need for orderliness and structure and their belief in research methodology grounded in the tradition of social science research methods*" (Thomas, 1984, p. 58). Furthermore, the policy area has been

criticized for "*...[lagging] all other in the development of a body of theory and formal analytic techniques*" (Anshen & Guth, 1973, p. 499). As a result, it was the definition from Schendel and Hofer (1979) that prevailed as the guiding definition of the newly formulated *strategic management paradigm* (Thomas, 1984): "*Strategic management is a process that deals with the entrepreneurial work of the organization, with organizational renewal and growth, and more particularly, with developing and utilizing strategy which is to guide the organization's operations*" (Schendel & Hofer, 1979, p. 11).

Even more important contribution of Schendel & Hofer (1979), also from the perspective of this project, was the conceptualization of the *process of strategic management*. According to Schendel & Hofer (1979), this process comprises of: *goal formulation; environmental (industry) analysis; strategy formulation; strategy evaluation; strategy implementation, and; strategic control* (see Figure 1).

Nevertheless, Schendel & Hofer's paradigm has also been criticized by Bower (1982) for fragmenting the strategic discourse into seemingly discrete parts, ignoring the business reality where these processes are integrated. Bower's concern was that such categorization would not help to organize the field, but rather result in siloing of the future research along the delineation resulting from the paradigm (Thomas, 1984).

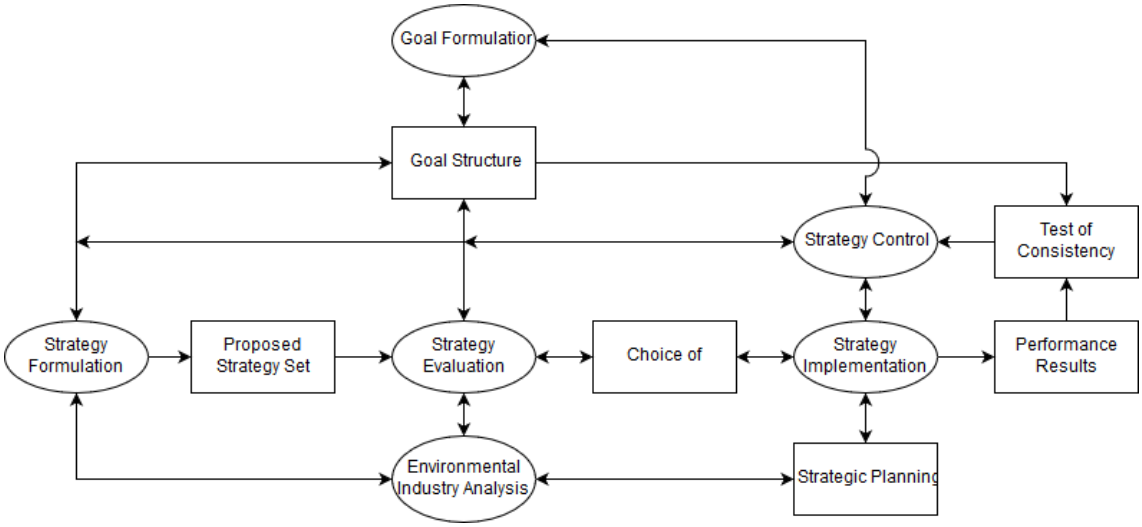

Figure 1: Strategic Management Process - adapted from *(Schendel & Hofer, 1979), (Thomas, 1984)*

From today's perspective, Bower's apprehension, to a certain extent, seems valid. Indeed, the field of strategic management continued to be fragmented. Nevertheless, Bower's argument about the integrated approach to strategic management in organizations is incorrect. In practice, strategic management is often split into areas of formulation, implementation, and control (Mintzberg, et al., 1998). Schendel & Hofer's approach,

where they divided strategic management into distinct sub-areas, is therefore not necessarily in conflict with the practice.

The main objective of this section was to outline historic development of the strategic management as an academic discipline. Despite (or because of) its relatively short history, this discipline lacks a formal definition. Instead it covers many different fields of thought, which can be conflicting in their view and understanding of strategy. What is important, however, is the definition of main elements of strategic process, developed by Schendel & Hofer (1979), who framed strategic management and set direction for the future development of the discipline. As a result, if this project is to be situated relative to the existing literature, it is first necessary to outline different schools of thought within strategic management and identify the one which this project adheres to.

2.1.2 Schools of thought in strategic management

The basic method to deal with a fragmentation of an academic discipline is to create a taxonomy, which groups together streams of thought according to the similarities in their fundamental theoretical and methodological principles (Elfring & Volberda, 2001). The objective of this section is to introduce functional categorization of strategic management as proposed by Mintzberg (1990) and, ultimately, to define this project in its terms.

Arguably the most comprehensive taxonomy of the strategic management was developed by Mintzberg (1990), who identified 9 schools of thought, each falling under one of the two larger streams – *prescriptive* and *descriptive* (Rouleau & Séguin, 1995) (Elfring & Volberda, 2001).

The first stream – *prescriptive* – covers 3 of the most influential and dominant perspectives on strategic management (Jofre, 2011). The schools in this group are defined by seeing strategy as result of a deliberate, centralized effort. In this sense, prescriptive schools attribute the role of strategy making to a very limited number of individuals within the organization, who in addition, posses formal training in the discipline (Yazdani, 2010). Prescriptive schools strongly focus on strategy creation – the process which in the context of these schools heavily depends on calculations and analyses (i.e. deliberate cognitive efforts) (Yazdani, 2010, p. 3). For strategies to be implemented, they must be clearly formulated, approved by executive management, and complemented by a detailed plan outlining the implementation and its control (Yazdani, 2010).

The second stream – *descriptive* – covers 6 schools of thought, which represent the opposite of prescriptive schools. In descriptive context, strategy is not a product of a deliberate planning performed by a small group of trained specialists. On the contrary,

strategy emerges from the continuous incremental cycle of collective organizational learning and implementing. Strategies emerge organically as a result of intraorganizational interactions (e.g. conflict and negotiation) and the influence of external factors. The role of executive managers is to guide the process and ensure best alignment between the strategies and external factors. Unlike in the prescriptive stream, strategies here are never explicitly formed, finalized, implemented or controlled (Yazdani, 2010).

2.1.3 Statement of theoretical positioning

In terms of Mintzberg's taxonomy, this project falls under the category of prescriptive stream of thought. More specifically, it subscribes to the positioning school, primarily represented by Porter (1980), as the main theoretical-methodological foundation for strategic analysis and formulation, performed hereafter. Adoption of the positioning school in this project was based on the fact that this school remains most prominent and widely covered element of the strategic management discipline. As such it represents a logical starting point in the evaluation of VBHC's impact on conventional strategies.

The core tenets of positioning school mostly resemble those of the others within the prescriptive stream of thought[4]. Nevertheless, it has two distinctive features, which justify its existence as a separate school of thought: focus on the content of strategy[5], and restriction of the possible number of strategies from theoretically infinite[6] to 3 generic ones[7].

By radically limiting the number of possible strategies the focus on the process of strategy formulation observed in the design and planning schools becomes superfluous, since the strategies are already defined. What gains importance is the process of selection where the company must choose which of the generic strategies to follow (Mintzberg, et al., 1998). With each of the generic strategies representing a specific position in the market, the objective is to identify one which best matches strengths of the company to the

[4] described at the end of page 9
[5] as opposed to the focus on the process of strategy creation
[6] strategy creation in design and planning schools leads to formulation of strategies that are unique to the company and their environment – theoretically allowing for infinite number of unique strategies (Mintzberg, 1990)
[7] ultimately expanded to 5 generic strategies based on the combinations of the 3

external environment. Ultimately, such strategy should lead firm to a position of competitive advantage (Grant, 2013).

The process of strategy selection in the positioning school is deeply rooted in the analysis of the industry, competitors and internal analysis of the firm. The task of selecting the appropriate strategy is performed by persons with analytical competences (e.g. analysts, consultants) who hold the "mandate" to do so (Jofre, 2011). The process is thus centralized, and strategies cannot emerge anywhere in the organization. Finally, when the analyst(s) reach a decision, the process of implementation and control is commanded by executive management (Mintzberg, et al., 1998). The implementation phase is largely out of the scope of positioning school.

Critique of the positioning school

Despite its undoubted significance and contribution to the strategic management, positioning school has also been subject of heavy criticism. Positioning schools' strict focus on strategy content and selection inadvertently results in negligence of the implementation phase. Although strategy formulation (selection in the case of positioning school) is certainly very important, the benefits can only materialize if the strategy is effectively implemented. In this sense, academics (or practitioners) adhering to the positioning school may depreciate importance and complexity of transforming ideas into concrete actions, or worse, consider successful implementation process as a matter of fact.

Second point of criticism concerns the concentration of strategic processes within limited number of people in the organization (strategists / analysts). Shielding of the formative strategic processes from the other members of the organization and their potential inputs prohibits organizational learning. As a consequence, strategic process becomes a discrete sequential activity instead of a continuous "microcycle" of learning and implementing.

Finally, the positioning school is criticized for too narrow focus and a problematic view of the environment where the strategic processes occur. By strongly focusing on the dynamics of the competitive environment within the industry, positioning school somewhat ignores factors external to the industry. Political and social factors, for example, may not directly affect intra-industrial dynamics, but since markets (and

industries) are essentially concepts defining certain interactions of social actors[8], these factors are still in reality shaping industrial (and organizational) landscape. Similar shortcoming is positioning school's view of external environment being relatively stable (Hattangadi, 2017). It is assumed that the situation observed[9] during the analytical stage would persist long enough as to allow for the selected strategy to remain valid after the implementation.

Implications for the project

In accordance with the main tenets of the descriptive approach, in this project, strategy formulation is seen as a conscious effort ultimately resulting in the explicit strategy for the company. Its formulation is performed by specific people, who have the mandate and knowledge to perform this task. Based on the positioning school, the process of strategy formulation is based on the analysis of the industry and subsequent selection of a generic strategy, which represents specific positioning within the market.

2.2 Value-Based Healthcare, Reimbursement, Procurement

This section outlines current state of the literature on Value-Based Healthcare and identifies gaps which this project aims to fill.

As a relatively new framework, with only 12 years passed since the publication of Porter's and Teisberg's pivotal book on the subject - *Redefining Health Care: Creating Value-Based Competition on Results* – VBHC gradually gains interest in the academia. Although the comprehensiveness of the academic sources on the subject is still relatively limited, it is already possible to identify several points of interest with regard to the VBHC.

The most developed body of literature looks at VBHC from the perspective of policymaking. This branch is best represented by Porter himself through a number of articles such as *Value based health care delivery* (Porter, 2008)*; How to solve the cost crisis in health care* (Kaplan & Porter, 2011), *A strategy for health care reform* (Porter, 2009)or; *Redesigning primary care* (Porter, et al., 2013). The emphasis is placed on the core concepts of VBHC and their relations to the organization of the health system. The

[8] such as firms, consumers, suppliers, etc.
[9] or predicted

perspective taken is that of a large-scale view of the VBHC implementation. Particularly covered is the issue of changes – political, organizational and financial - that are required for creation of (right) competition within the healthcare, and the alignment of healthcare providers' interests with those of the patients.

Second set of literature looks more closely on the issues of financing – specifically insurance, reimbursement, and purchasing. The former category is mostly covered in the context of the U.S. healthcare system, as Value-based insurance design (VBID) is being used in there. Although it could be argued that VBID is not entirely within the scope of VBHC it is very much close the VBHC in terms of its objective to maximize quality care delivery relative to cost (Butcher, 2009). The main contribution with regards to the VBID is made by the Center for value-based insurance design at the University of Michigan, with the initial conceptualization done by Michael Chernew and Mark Fendrick in *Value-based Insurance Design: Aligning Incentives to Bridge the Divide Between Quality Improvement and Cost Containment* (Fendrick & Chernew, 2006). More important for this project, however is the literature on the financing of healthcare delivery (reimbursement) and on the procurement of medical devices.

Reimbursement in healthcare is historically a well-covered topic. Existing literature mostly reflects current developments in the field and therefore it is possible to see several stages of development, from cost-based approaches and prospective payments through fee-for-service (FFS) and capitation to the most recent diagnosis-related-groups (DRGs) and pay-for-performance (P4P) also known as value-based payment models[10]. It is the latter category that is of interest in the context of this project.

Despite the number of publications on P4P increasing (Herck, et al., 2010) their scope remains relatively narrow. The most studied aspect is the impact of P4P systems on the quality of healthcare provided and cost effectiveness of healthcare delivery. The findings from these studies offer conflicting findings and are not easily generalizable for predictions about the outcomes of P4P system implementation across health systems (Herck, et al., 2010) (Eijkenaar, et al., 2013). Still, these evaluations are useful to identify design features and mechanics of the systems they study, which is highly relevant for the analysis in this thesis.

[10] generally abbreviated as VBP – although within this project the abbreviation VBP is used for value-based procurement

The limiting factor is that the majority of P4P literature focuses on the U.S. healthcare system even though P4P systems are also developing in the other countries. This knowledge gap is somewhat reduced by the similarity of some of the basic features of P4P systems, regardless of the country in which they are implemented. More clarity to the issue has been brought by Frank Eijkenaar (2011) who studied P4P systems in the additional countries (9) and whose work will be used in this project. In addition, theoretical basis of this project is complemented by a detailed overview of payment systems in the European countries developed under *Health Systems in Transition* project by the European Observatory on Health Systems and policies.

What is lacking with regards to the value-based reimbursement literature is any explicit connection to the potential outcomes for the companies supplying medical technology[11]. The word *strategy* is used in relation to the P4P systems but in the context of overall healthcare rather than companies (e.g. *What are the most effective strategies for improving quality and safety of health care?* (Scott, 2009)). The connection between the implementation of P4P reimbursement systems as a part of VBHC framework and businesses (and their strategies) is an unstudied area which this project covers.

The final, and arguably the most important aspect of VBHC considered in this study, is the value-based procurement (VBP). Surprisingly, VBP has not yet received deserved attention in the literature on VBHC, despite its potential to drive the transformation of healthcare. The core idea of VBP is that the objective of the purchase of goods or services is to maximize value (where value = benefits – cost) instead of minimizing nominal cost (Chick & Handfield, 2015). As a result, under VBP, it may be beneficial to procure product or service that is initially more expensive, if the cost-benefit spread of such offer is higher than that of the competing offer, even though the second offer may be nominally cheaper[12]. The VBP has a legal support in the EU legislation under the Directive 2014/24/EU of the European Parliament and of the Council on public procurement, where the practice is conceptualized as *Most economically advantageous tender* (MEAT).

[11] except for pharmaceuticals

[12] e.g. a magnetic resonance (MR) priced at €1.5m with potential revenue generation of €2.5m over the lifetime of the device may be preferred to the MR priced at €0.86 m and potential revenue generation of €1.7m, as €1m spread of the first offer dominates €0.84 spread of the second offer

The most developed literature on the subject of MEAT award mechanism is within the context of the Dutch construction sector, which is increasingly utilizing this mechanism. The biggest contribution to this topic has been made at the Delft University of Technology with a number of works on BVP and MEAT (Santema, et al., 2011), (Dreschler, 2009), (Dreschler, et al., 2007). Impacts of MEAT on strategies of firms has already been studied, although not in relation to healthcare. Especially important is the work of S.M.H de Vrind (2010), who studied effects of MEAT award mechanisms on the competitiveness of a firm active in the construction industry.

Based on the review of existing literature, there is no equivalent of de Vrind's view of MEAT in terms of strategy related to healthcare. At the time of writing, the most significant exploration of VBP within healthcare remained very sparse, with articles focusing on the issue of barriers for VBP in healthcare (Meehan, et al., 2017) or VBP implementation in Canada (Prada, 2016). Research on MEAT in healthcare has been limited to efforts of Nordic medical device industry associations[13] or commercial reports from MedTech Europe and Boston Consulting Group. Considering the big gap[14] in the study of dynamics between VBP/MEAT and competitive environment for businesses within healthcare this project aims to address this problem by providing an early contribution to the subject.

2.3 Summary

The objective of this section was to define theoretical foundations of this project and identify gaps in the existing knowledge. As outlined in the Figure 3. it is possible define field of inquiry in this project as a matrix made up of interactions between different subjects – broadly falling into categories of strategic management and VBHC.

In relation to strategic management, the objective of this project is to take knowledge that is already existing (competitive positioning theory) and apply it in a new context, ultimately reaffirming its continuing and validity. Richness of the existing literature on the subject leaves little space for generation of completely new theories but rather points to the continuing questioning and testing of the already developed theories – a role assumed hereafter.

[13] Medtek Norway; Medico Industrien; Healthtech Finland; Swedish Medtech; Sailab;
[14] compared with the existence of similar research in the construction industry

Maturity of the literature on VBHC, however is much lower. So far, the focus has been on the *big picture* issues such as translation of the framework into policies, integration of VBHC with insurance plans, development of mechanisms for measuring value and implications for healthcare providers. Going deeper into the matters of VB reimbursement and VB procurement reveals severe gaps in coverage of these areas.

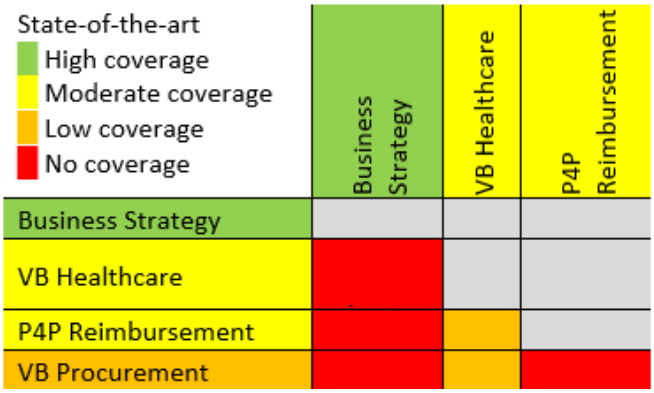

Figure 2: State of the art in the academic literature

The situtation further worsens when exploring literature on VBHC and strategy from the cross-curricular perspective. As illustrated by the Figure 3, there is an acute lack of research examining relationship between VBHC and business strategies. This knowledge vacuum is particularly striking after considering size of the healthtech market, awareness of the VBHC in practice, and the scale of disruptive potential of VBHC on healthcare as a business. The ambition of this project is to address this gap in knowledge by exploring the VBHC > Reimbursement > Procurement > Strategy continuum.

3 Theoretical framework

3.1 Strategy

Origins of strategy

The cause for the inconsistency in the understanding of the term may partially be attributed to wide and liberal usage of the term, but from the academic perspective there are two key factors most likely responsible for the lack of harmonization of the concept – organic emergence of the discipline and changing business environment (Grant, 2013).

Existence of the concept outside of the business context dates to 500 BC, with Sun Tzu's The Art of War often regarded as the foundation of the strategic literature. The origin of the term, however, links to ancient Greek where *strategia* connoted "generalship" (Grant, 2013). While historically the term has been linked with warfare, the core issues of positioning, competition between the actors, and response to the changing conditions (environment) can easily be applied to business situations (Jofre, 2011, p. 3).

Development of strategy within business remained largely non-existent until latter half of 1800s. Before this time, most of the companies were relatively small enterprises with minimal impact on the markets they were operating in. As such, these firms had no need to develop advanced "plans" regarding the use of resources or positioning relative to competitors. However, the growth of mass markets incentivized expansion of the operations ultimately leading to a rise of M-form firms[15] defined by a relatively complex structure and substantial influence on the market (Ghemawat, 2002). With the ability to modulate competitive environment within the industry and a need to manage a variety of resources came the need for a structured approach to these new challenges (Ghemawat, 2002).

Strategy as a working concept

Until this point, the term strategy has been in different forms mentioned XXX times without causing any misunderstanding or confusion. Undoubtedly, also with regard to its long history, strategy is extremely familiar as a term. Still, usage of the term in academic context requires specific conceptualization – if not definition – to avoid any ambiguity that may otherwise occur.

Arguably the best approach to the delineation of strategy was that of Henry Mintzberg (1987) who recognized problem with usage of a single definition of strategy. In his article, Mintzberg (1987) argues that strategic management should use multiple explicit definitions of strategy. The basis for this argument is that even though there is a single definition, implicit usage of strategy in strategic management often differs from that definition (Mintzberg, 1987). To avoid such situation, Mintzberg proposes 5 "definitions" of strategy, which should account for the most common views of strategy:

a) Plan (intended strategy) – a most common view which defines strategy as future oriented conscious and deliberate effort. Here strategy represents a set of intended actions that are to be taken in future, with the aim of reaching a specific objective;
b) Pattern (realized strategy) – according to Mintzberg (1987), strategies can also emerge as a result of past actions. In this way, strategy is seen as a function of consistency in the past behavior – whether intended or unintended.

[15] firms whose organizational structure is defined by presence of many divisions

Rather than seeing realized strategy as a substitute to the intended strategy, Mintzberg (1987) show the two as being on the opposite ends of the continuum.

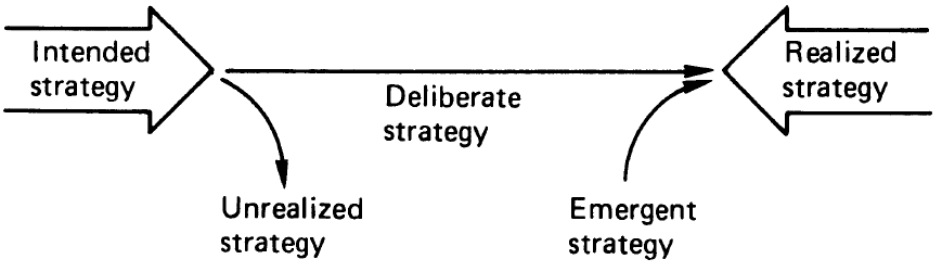

Figure 3: Strategy Continuum (Mintzberg & Waters, 1989, p. 5)

The key observation here is that intended strategies do not always fully translate to a reality, and nor are realized strategies based solely on conscious plans. From this perspective there is an equivalency between a producer who **consistently** sells products at discount due to a lack of demand at full prices, and a producer selling products at a discount intentionally. The realized strategy of both producers is low-cost strategy;

c) Position – another view of strategy is that of a position. This view sees strategy as a link between the organization and its external environment (industry) Again, according to Mintzberg (1987), this definition of strategy is not in conflict with the others, as they can to a various extent overlap, as illustrated above[16];
d) Perspective – fourth view of strategy is strongly based on the internal perceptions within a firm. Much more than the positioning view, perspective is concerned with values and ideals existing in the company. Here the strategy defines vision and direction of the company from the qualitative perspective (e.g. cutting-edge innovator) rather than economic perspective (e.g. premium brand), although the complementarity of the two views is apparent;
e) Ploy – the final view of strategy is rather limited as it only relates to "*a specific maneuver intended to outwit an opponent or competitor*" (Mintzberg, 1987, p. 12). Ploys can be used as a part of greater strategy, but it is unlikely that they can be a sole component of strategy in the longer-term. If a company engages in a

[16] The low-cost strategy of the two discount manufacturers is a position. In case of the first producer the positioning strategy is also a strategy as pattern, in case of the second producer the low-cost strategy is simultaneously a plan.

> ploy, it is essentially signaling certain intentions to the competitors, with the aim of altering their actions. This can only be effective if the competitors believe in the capability of the signaling company to carry out the ploy.

While Mintzberg's (1987) framework of 5Ps manages to encompass complexity of strategy, it has its own pitfalls. By conceptualizing strategy as an umbrella term for 5 distinct views, Mintzberg (1987) further contributes to the fragmentation of strategic management and confusion about strategy as such. On one hand, Mintzberg (1987) criticizes "single definition" approach by saying it does not account for the complex nature of strategy. On the other hand, he himself claims that 5Ps are often interrelated and complementary. If strategy can be defined as one or all Ps at the same time, is there a value in distinguishing between the Ps?

In my view it does, but only if the 5Ps are complemented with a functional description of strategy. After identifying different sources (emergent/deliberate) and forms (patterns/positions/plans) of strategy, it is necessary to define common root of these sub-concepts – that is the function of strategy.

Ideally, strategy fulfills several vital functions in the organizations. First of all, strategy materializes organizational vision into concrete targets which are to be pursued. In this way, it helps to identify missing resources that are required to reach the target by*"[creating] an extreme misfit between resources and ambitions"* (Hamel & Prahalad, 1993). This misfit then serves as a motivating factor in driving organization (and its members) towards the development of measures necessary to achieve set goals (Grant, 2013). Secondly, strategy serves as a coordinating device facilitating alignment of the organizational members towards common objectives. In a way, strategy functions as a communication medium *"by which the CEO can communicate the identity, goals, and positioning of the company to all organizational members"* (Grant, 2013, p. 17). Thirdly, strategy ensures consistency in the external actions of organization, by acting as a decision support for the organizational members, who are supposed to adhere to the selected strategy in terms of their decision making. Finally, as a result of all these factors, strategy gives organization an identity and differentiation from the other entities (Mintzberg, et al., 1998).

Returning to the objective of this chapter and having identified functions and forms of strategy, it is possible to define strategy with a single definition as:

"*The means by which an individual or an organization accomplishes its objectives*" (Jofre, 2011, p. 5)

where the means are defined by Mintzberg's five Ps[17] and the objectives, in the context of this paper, is the outperformance of the competition and achieving superior profitability by means of building competitive advantage (Thompson, et al., 2016).

3.2 Generic strategies and competitive advantage

In the previous chapter, I have established that the ultimate objective of the strategy should be to ensure superior profitability to the firm adopting it. From the strategic perspective there are two factors defining profitability of the company – industry attractiveness and competitive advantage (Grant, 2013).

The former aspect is largely attributed to the scope of *corporate strategy* – where the firm has to decide which industries it wants to compete in. As each industry has different profitability[18], the firm's decision of *where to compete* will bear effect on its overall profitability (McGahan & Porter, 1997) (Grant, 2013). Since this analysis works with an assumption that the health-tech firms are already set on the corporate strategy[19] it is the latter aspect which is of interest here.

The second aspect determinant of the firm's profitability is the way it decides to compete in the industry. With the other firms contesting for the same customers, it is important to engage in some form of differentiation, which sets the firm apart from its competitors. Often called *competitive advantage* – a term lacking proper conceptualization just like strategy (Klein, 2001) – this differentiation represents the core of the *business strategy*.

Depending on the school of thought there are multiple ways of gaining competitive advantage. In fact, the design and planning schools of strategic management suggest that each firm requires a specific business strategy, specifically suited to its circumstances – theoretically allowing for infinite number of different strategies. While it is true that the strategies of the two firms will always to some extent be unique, it is also possible to group these strategies into comparable categories. Therefore, in the broadest sense, the competitive advantage can be gained by either *"giving buyers what they perceive as superior value compared to the offerings of rival sellers or giving buyers the same value as others at a lower cost to the firm"* (Thompson, et al., 2016, p. 5).

[17] Plans, patterns, positions, perspectives, ploys
[18] For example, profitability of IT industry is higher than mining industry
[19] And that they will continue competing in the health-tech industry

Generic competitive strategies

The common features of the business strategies have also been observed by Porter (1980), who introduced three generic strategies which may create competitive advantage:

a) overall cost leadership;
b) differentiation;
c) focus.

Although Porter (1980) warns against the combination of the basic generic strategies, over the years the three strategies were expanded by additional categories, namely (Thompson, et al., 2016):

d) focus and cost leadership / focus and differentiation (as sub-categories of Porter's focus strategy);
e) cost leadership and differentiation (or "best value" as a combination of differentiation and low-cost strategies).

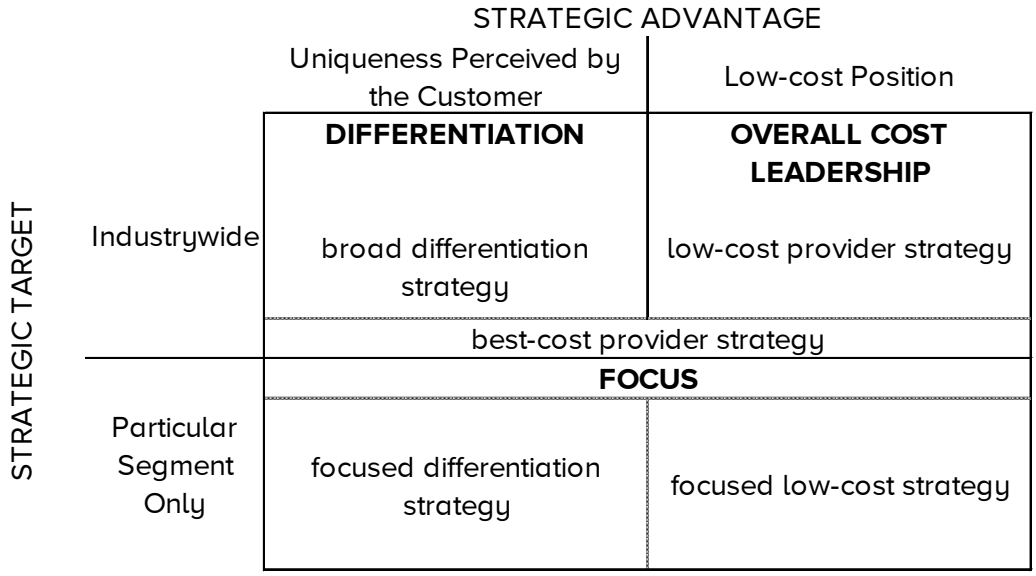

Figure 4: Generic Strategies (Porter, 1980, p. 39) (Thompson, et al., 2016, p. 7)

By pursuing **cost leadership strategy** (low-cost competitive advantage) firm chooses not to differentiate itself from other companies in terms of products or services offered. On the contrary, it aims to match offerings of competitors but do so at the lowest possible

cost (Hill & Jones, 2010). Company has several ways to achieve low costs. Among the most important are economies of scale, excellent cost-control in manufacturing and other expenses, usage of advanced proprietary technology or access to cheap resources (Porter, 1985). It is important to note that low-cost does not have to translate into low price. Theoretically, cost leader can charge same prices as the competition and still have competitive advantage by achieving higher margins than the competition (achieving the goal of higher profitability).

From the positioning perspective, cost leadership strategy has several advantages. By having minimal possible costs, company is well protected against potential price-wars as it can sustain profitability at price levels where competition generates losses. In addition, cost-leadership relatively reduces power of suppliers and buyers and creates barriers to entry of new potential competitors (Porter, 1980).

Cost leadership, just like any other strategy is susceptible to several risks. Noticeably it requires constant modernization of assets and processes and constant control. Low-cost position is extremely vulnerable to technological change which may render past investments and learning obsolete. Due to the lack of differentiation, low-cost strategy does not completely protect from imitators and entry of other low-cost firms. Also, the low-cost position is only viable if one firm occupies it, otherwise the competition for market share (which is of utmost importance to the cost leader) would drive prices below the sustainable level, ultimately leading to repositioning or bankruptcy of one of the competitors (Porter, 1985).

Second approach to getting higher profitability is pursuing the strategy of **differentiation**. In this position, company focuses on differentiation of the products and services from the competition. By satisfying specific needs of customers, differentiator[20] can charge premium prices, as competitors cannot offer qualitatively same products or services. Depending on the situation, firm can select from a multitude of differentiating factors, such as service quality, innovativeness of the products, unique design, or just perceived desirability of the brand (Gimbert, 2011). The source of

[20] a company that pursues the strategy of differentiation (Hill & Jones, 2010, p. 161)

competitive advantage for differentiator is the ability to charge a price premium over the competitors who, due to a lack of differentiating features must charge lower prices. The price premium, however, must exceed the cost of differentiation (Porter, 1985).

Advantages of the differentiation strategy are the higher customer loyalty and their lower price sensitivity, better protection against substitutes, and more difficult entry to the market[21]. Unlike with the low-cost strategy, it is possible for multiple firms in the industry to follow differentiation strategy, if the differentiating factors are different. By catering to different customer needs, market share will be expectedly lower, but ideally should be compensated with above-average returns (Porter, 1980). The major risk of this strategy is the customers' unwillingness to pay the premium for the differentiation – either due to excessive spread between cost leaders and differentiators or customer's decreasing need for differentiation, which may occur as industry matures (Porter, 1980).

The final generic strategy is **focus** or specialization. This strategy is quite flexible, as it can incorporate both the elements of differentiation and cost leadership. The most important factor here is that focuser decides not to serve the whole market, but rather only specific part of it (either in geographical terms or product terms) (Gimbert, 2011). The source of competitive advantage for the focuser stems from the ability to "*serve its narrow strategic target more effectively or efficiently than competitors who are competing broadly*" (Porter, 1980, p. 38). The focuser can therefore differentiate himself on the capability of to better[22] address the needs of the customers within the segment and/or serve this segment at lower costs than the competition (Porter, 1980). Besides the risks associated with the differentiation and low-cost components, focus strategy is susceptible to narrowing of the differences between the target segment and overall market. If this difference ceases to exist, focuser will lose the competitive advantage and struggle on the broad market. Alternatively, competitors may "*find submarkets within the strategic target [segment] and outfocus the focuser*" (Porter, 1980).

In summary, Porter's generic strategy model suggests that a firm, in order to be competitive has to adopt either of the 3 generic strategies, otherwise it risks being "*stuck in the middle*" (Porter, 1980). In this position, firm struggles to remain profitable as it has no competitive advantage. On one end, low cost competitor has much higher

[21] as the new entrant is facing loyal customer base and is forced to create own differentiation strategy
[22] compared with the broadly focused competitors

profitability at the same price level as the stuck in the middle firm. On the other end, differentiated competitor commands a proportion of loyal customers on the market and achieves above-average returns. In terms of focus, stuck in the middle firm is unable to leverage specialization on the smaller sub-segment of the market. Without any competitive advantage, firm is subject to at best average profitability and a lack of strategic direction.

There has been a debate whether Porter's (1980) assumption that stuck in the middle firms will suffer from lower profitability. Research on the issue shows that in fact combination of several generic strategies (hybrid strategies) can result in higher profitability compared the firms pursuing only one generic strategy (Pertusa-Ortega, et al., 2009). With regard to the stuck in the middle position it is not absolutely certain that it leads to lower profitability. Paradoxically, stuck in the middle may even be seen as a strategy of its own assuming already existing polarization of the market in terms of generic strategies. It is therefore important to use Porter's (1980) generic strategies model with a bit of a caution and distance. While its use is beneficial for the basic modeling of possible positioning in the industry, its literal application in the process of business strategy creation may be problematic.

3.3 Determinants of industrial competition

The other important aspect of strategy formulation is the evaluation of industry the firm is competing in. This process gains further significance when the industry is due for a significant change, as is the case of healthcare. Assuming that the VBHC will open up possibilities for new strategic positions in the market, it is crucial to gain thorough understanding of the industry dynamics and the drivers of the competition. According to the industrial organization theory, the competition within the industry is not random. Instead, it is a result of structural factors that are beyond the scope of the direct competition between the firms active in the industry. Porter (1980) conceptualized these factors in his Five Forces framework:

Force	Factors
Threat of Entry	- Economies of scale - Differentiation - Capital requirements - Switching costs - Distribution channels - Other cost advantages - Policies
Intensity of Rivalry	- Number of competitors - Industry growth rate - Fixed costs - Differentiation - Switching costs - Exit barriers - Commitment
Substitute Products	- Imitability - Switching costs - Availability of substitutes
Power of Buyers	- Buyer's share on total seller's revenues - Product expenditure as a share of total buyer's expenses - Differentiation - Switching costs - Profitability of buyers - Backward integration of buyers - Importance of product for buers
Power of Suppliers	- Competition between suppliers - Substitutability - Imporance of the industry for the supplier - Importance of the supplier for the buyer - Differentiation / swithcing costs - Forward integration of suppliers

Figure 5: Porter's Five Forces and the factors driving their strength (Porter, 1980)

The strength of each factor depends on the factors described in the Figure 6. The importance of the Five Forces is not universal and changes across the industries. For this reason, it is crucial to define which forces are pertinent to the industry in question. In general, the attractiveness (i.e. profitability) of the industries is negatively correlated with the strength of the Five Forces (Figure 7). With the increasing number of strong Forces, the company will face more competitive challenges. However, the profitability is not primarily driven by the number of strong forces, but rather the combined strength of the forces. It is theoretically possible to observe an

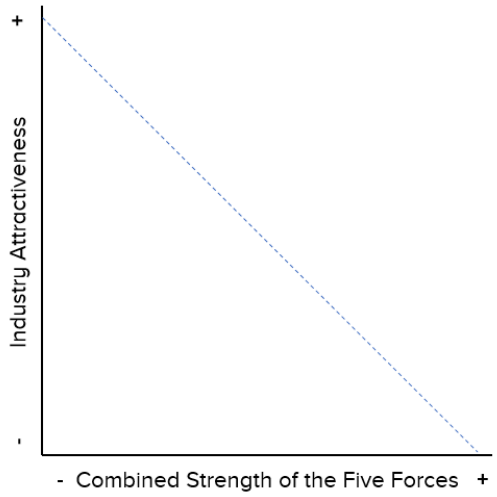

Figure 6: Industry attractiveness /Five Forces

attractive industry with the presence of all five forces, or an unattractive industry with the presence of a single, but very strong force (Thompson, et al., 2016).

3.4 Value-based Healthcare (VBHC) – Defining value

Value-based Healthcare (VBHC) as a framework has been introduced in 2006 by Michael Porter and Elizabeth Teisberg in their book *Redefining Health Care*. In 12 years since the publication, the idea of healthcare based on value instead of volume has been gaining increasing attention and support in both public and private sector. Teisberg's and Porter's (2006) motivation for the development of a new healthcare framework has been driven by problems defining US healthcare – notably high costs, low quality and increasingly difficult access to healthcare. While arguably the healthcare in Europe faces different problems, it still must balance these three factors.

According to Porter and Guth (2012), health systems globally ignore value maximization for individual patients and instead focus on health on the population level. The outcome of such thinking is a focus on access to healthcare, or in other terms, aggregate volume of healthcare delivered to the population. While the access to treatment is undeniably a precondition for a well-functioning health system, it is not sufficient.

This becomes apparent if we look at healthcare from the perspective of a patient and compare it to the view of health system. For example, if a patient undergoes surgery for an unspecified medical condition the possible outcomes of the intervention are following: a) patient is cured; b) patient develops secondary condition as a direct preventable result of the intervention; c) condition remains unchanged.

It is axiomatic, that the value of the treatment cannot be higher than the value of the cure. Therefore, for the patient $treatment \leq cure$, but the same is not true from the perspective of health system. In all three cases, patient had access to healthcare and received treatment. Despite the outcomes of the intervention being positive in case a), negative in case b), and neutral in case c), health provider fulfilled the obligation of administering treatment and created a case for reimbursement, where the payments for a), b) and c) are equal.

The example illustrates essential problem of the current healthcare - volume does not correspond to value for the patients yet it does for healthcare providers and health plans. This simple misalignment gets magnified through the mechanism of healthcare financing and results in inflated costs and inconsistent quality of care delivery. The resolution to this problem requires a definition of value that is to be used as aligning force of healthcare. However, since the perceptions of value vary between the stakeholders, it is first necessary to define the most important actor.

According to Porter (2010) *"value should always be defined around the customer, and in a well-functioning health care system, the creation of value for patients should determine the rewards for all other actors in the system"*. This follows elementary economic logic, where the basis for exchange between two parties depends on buyer's willingness to pay only if the perceived benefit of such exchange outweighs nominal cost of the transaction. Returning to the previous example, patient's valuation of treatment resulting in neutral or negative outcome is zero, yet provider still gets rewarded.

After designating patient as the central figure of healthcare, it is possible to proceed with the definition of value in healthcare as a central tenet of Porter and Teisberg's work (2006): *"value...is the quality of patient outcomes relative to the dollars expended"* (p. 98).

$$Value = \frac{Quality\ of\ patient\ outcomes}{Cost}$$

The formula looks to be very simple, but deceivingly so. The dimensionality of numerator is immense and can comprise of a multitude of factors. Besides survival, quality of patient outcomes should consider overall benefits delivered to patient. This requires a shift in the perception of healthcare delivery from discrete actions to complete care cycle. In addition, the basic unit of healthcare should change from specific medical interventions to medical conditions (e.g. hip joint replacement or diabetes) (Porter & Teisberg, 2006).

The use of complete care cycle and medical conditions would allow to create a basis for comparison which, through competitive forces, would drive the value for patients. If for example two hospitals perform hip-replacement surgery where patient of Hospital A can walk 1 day after discharge, and patient of Hospital B can walk 3 days after discharge, then for patients $Value\ A > Value\ B$. Nevertheless, in the case-based view $Value\ A = Value\ B$. If the nominal quality of patient outcomes for this treatment is 12,000, where the patient expects 1-day recovery, and the patient quality decreases by 2,000 per each additional day, we can model the situation as in Figure 8.

Consistent with the statement above, Hospital A dominates Hospital B in terms of value delivered to the patient. Hospital B, however, delivers treatment cheaper than Hospital A, which means that from the perspective of a health plan, which rewards cases instead of patient outcomes, Hospital B is more efficient (approximately +0.8 value units per € spent).

	Value for Patient	Value Case-Based	Cost	VBHC
Hospital A 1-day recovery	12,000	12,000	€4,000	$Value = \frac{12{,}000}{€4{,}000} = 3.00$
Hospital B 3-day recovery	8,000	12,000	€3,900	$Value = \frac{8{,}000}{€3{,}900} = 2.05$
Hospital C 0-day recovery	14,000	12,000	€4,300	$Value = \frac{14{,}000}{€4{,}300} = 3.26$

Figure 7: Value

The problem becomes even more apparent if we look at the cost structure of the intervention (Figure 9). Hospital B, which provides less value to the patients can generate higher profits than Hospital A through cost savings, since reimbursement is based on number of cases. Hospitals are thus incentivized to save costs relative to the volume of care provided, which results in a flawed competition at the expense of patients.

	Hospital		
	A	B	C
Diagnostic Procedures	€153	€153	€153
Imaging	€50	€50	€150
Normal/intensive ward	€1,232	€1,232	€1,344
Operation	€1,512	€1,412	€1,600
Overhead	€1,053	€1,053	€1,053
Total Cost	**€4,000**	**€3,900**	**€4,300**
Reimbursement	€4,100	€4,100	€4,100
Difference	€100	€200	-€200

Figure 8: Cost Structure of a Hip Replacement Surgery

Finally, consider a value-maximizing provider C who manages to increase patient value above the standard industry level, but does so at a cost exceeding reimbursement level. From the patient perspective, increase in utility outweighs the increase in cost, however, from the health plan perspective, provider C delivers the same treatment as providers A and B at a significantly higher cost. As a result, provider C is disincentivized from the provision of superior care, as his economic outcome is negative.

The example above illustrates concern of Porter and Teisberg (2006) where the focus is on procedures involved in the treatment (diagnosis, surgery) instead of a condition itself (problems with hip joint decreasing the quality of patient's life). According to Porter and Guth (2012) "*patient's medical condition is the fundamental unit of value creation in the health care system*" (p. 28). It should not be fragmented into sub-conditions (co-morbidities) nor into discrete stages (diagnosis, surgery, follow-up examination, etc.). Instead the focus should be on the "*complete cycle of care for the medical condition, extending from preventive care through screening, diagnosis, treatment, rehabilitation, and long-term health management*" (Porter & Guth, 2012, p. 28).

Implications for health-technology firms

VBHC represents an immense opportunity for health-technology firms. In theory, focus on value instead of volume should open new possibilities of competition, where innovation and differentiation get rewarded (Deerberg-Wittram, et al., 2017). So far, however, health-technology companies have been blamed for having negative impact on healthcare.

There were multiple studies linking increase in healthcare spending with the increasing proliferation of health-technology. Porter and Teisberg (2006) argue that while health technology suppliers bear partial responsibility for reinforcing the volume-centric orientation, there were no studies focused on measuring actual value delivered by these technologies. Now however, health-technology firms are in a position where they can leverage their knowledge of the value-generating potential of their devices and support health providers in delivering value to patients (Deerberg-Wittram, et al., 2017).

Critique of VBHC

So far, VBHC as proposed and promoted by Porter has received relatively mild criticism, which is surprising considering its immense proliferation. Pedersen (2017) pointed out, that the problem of Porter's VBHC is that it is largely based on the US healthcare system. From the European perspective, however, VBHC may look more like a pseudoinnovation. In particular, Pedersen (2017) questions whether the bundling (medical condition / complete care cycle) is in fact different from DRGs which are already in use.

More substantial is the critique of the VBHC's basic assumptions proposed by Ebbevi (2016). According to his research, VBHC's assumption that only outcomes are important to patients is not always valid (Ebbevi, 2016). In addition, at this point, VBHC lacks robust empirical support, which may partially be caused by the fact that many of the multitude of assumptions made by VBHC are very difficult to empirically test. As a result, VBHC at this point truly represents a guideline for the future of healthcare, rather than a fully developed framework.

3.5 Incentive system in Healthcare - Reimbursement

Reimbursement in healthcare represents main tool for the financing of services rendered to the consumers – patients. In most developed countries, patients pay for healthcare in a form of taxes or through insurance policies (or both). As such, healthcare represents a system where the role of consumer and payer – under normal circumstances present with one entity - is artificially split between two actors. The patient retains the role of consumer and the role of payer is conveyed to an entity responsible for the coverage of expenses incurred by the consumer. Depending on the health system, this entity could be governmental organization, department, public insurer, private company or other entity – collectively termed *health plan* hereafter. The resulting structure of health system is thus based on the interaction of three main actors as depicted in Figure 8.

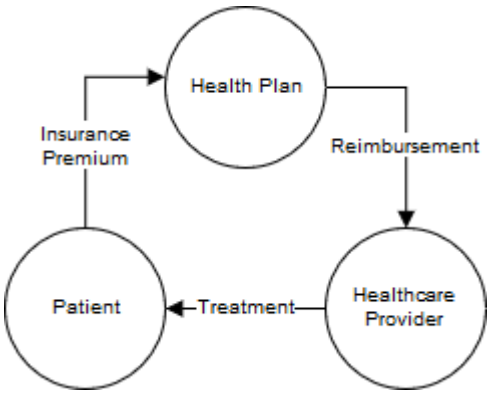

Figure 9: Simplified Health System

Immediately obvious feature of this organization is the conflict in the objectives of the actors. Patients are seeking maximization of health outcomes from the treatment; health plans are minimizing payments to the providers; and providers are maximizing revenues. Under normal market conditions[23], healthcare provider's revenues would be directly tied to the utility (in the form of health outcomes) delivered to the patient.

Vesting the payment obligation with health plan creates basic agency problem where patients are unable to directly incentivize healthcare providers to increase the quality of the services (or at least match the level of service to the patient's ability to pay). Instead, the outcomes for patients are dependent on the setup of the reimbursement system used to pay for the healthcare.

[23] where consumer is simultaneously payer

Volume-base reimbursement

The most common way of paying for healthcare is based on the volume of patients treated and/or procedures administered. In general, volume-based reimbursement is usually linked to the Fee-for-service model although in principle capitation, DRGs and prospective budgeting models are also based on volume.

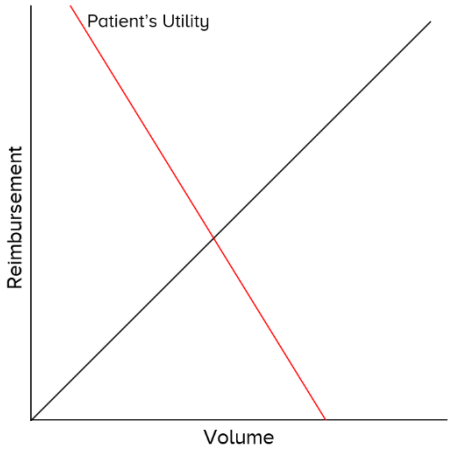

Figure 10: Volume-based reimbursement

Figure 9 illustrates a basic volume-based reimbursement model for a Computed Tomography (CT) examination. As a source of X-ray radiation, the utility CT examinations from the patient's perspective follows a decreasing curve (with the possibility of reaching negative values). From the perspective of patient, the utility of a CT examination is defined as diagnostic outcomes less the cost of examinations[24]. Since the patient's utility curve is downward sloping, their preference is to undergo lowest possible number of examinations with the highest diagnostic value.

On the other hand, providers following objective of revenue maximization are incentivized to provide large volume of examinations as their revenue curve is defined as $TR = p \times v$, where TR is total revenue, p is price per examination, v is the volume of examinations.

From the perspective of diagnostic imaging manufacturers, care providers subject to volume-based reimbursement are likely to demand low-cost - high output devices, making innovativeness and scanning quality secondary. In strategic positioning terms, volume-based reimbursement incentivizes adoption of overall cost leadership strategy, as differentiation factors are relatively inconsequential.

[24] in terms of time, discomfort, radiation exposure, etc.

Value-based reimbursement

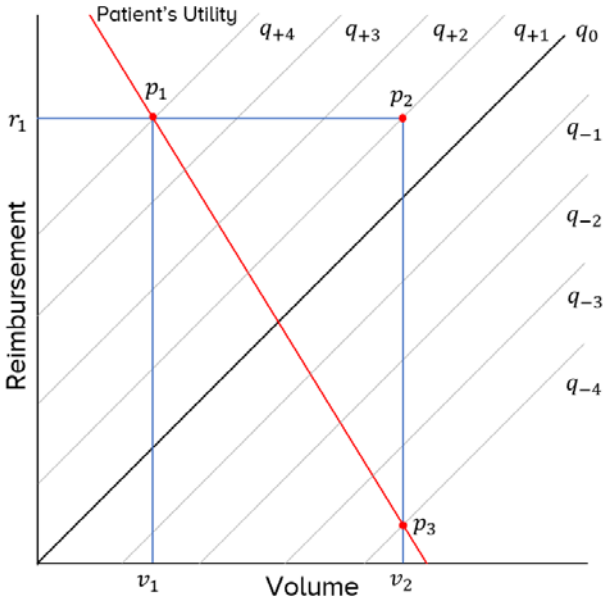

Figure 11: Value-based reimbursement

Simplified way of improving the outcomes for patients and aligning their objectives with those of the providers is to extend the reimbursement model with a quality component. Such model is presented in the Figure 10.

While the correlation between the volume and payment is still present[25], providers have the option of shifting their reimbursement curve by altering the quality of the services provided. In this way, they can generate same revenues at lower volumes, and at the same time maximize outcomes for the patients. In the Figure 10, by shifting from original quality q_0 to higher quality q_4 the provider can retain same revenues at much lower volumes – meaning lower personal costs and lower strain on the equipment. At the same time patients do not have to incur disutility of higher examination volumes.

The model still allows providers to increase volume (e.g. v_1 to v_2) by shifting to lower quality (q_{+4} to q_{+2}) while retaining same revenue (r_1), although the patient's perception of quality would drop lower on the patient's utility curve (point p_3 equivalent to a quality level of q_{-4}). Still, this may be a viable alternative for providers serving large populations (maximizing healthcare accessibility) or providers focusing on less complex examinations, where the quality tradeoff bears less significance[26].

From the perspective of the diagnostic imaging manufacturers, introduction of the quality component in the reimbursement calculation opens possibilities for the diversification of the product portfolio. Manufacturers have the possibility to differentiate their products in terms of unique features and advanced technologies

[25] the relationship will continue to exist even under purely value-based model, although the volume in this context refers to units of value generated rather than nominal number of examinations performed
[26] Lower slope of the patient's utility curve

contributing to the improvement of care delivery to the patient. In addition, focus on quality increases viability of specialized equipment and creates space for strategies of focus.

3.6 Procurement

Just like the reimbursement represents main interacting mechanism between the healthcare providers and health plans, procurement defines the relationship between suppliers – in this case health technology companies – and healthcare providers. As European health systems are primarily financed through public funding, procurement of medical equipment - especially health technologies whose monetary value often exceeds applicable thresholds - is usually subject to the process of public tendering.

Procurement process generally consists of six stages namely: *"determining specifications; supplier selection; contracting; ordering expediting, and finally follow-up and evaluation"* (Stilger, et al., 2017, p. 91). Most important from the perspective of this paper are the first two stages as these are most significantly impacted by the shift towards the value-based framework. More precisely, the first stage relates to the process of defining basic qualification criteria for the suppliers. With regards to the changing reimbursement methods (and incentives for the healthcare providers) it is likely that the basic procurement specifications will change to reflect new needs of the providers. It is however the second stage, where the impact of value-based approach materializes the most. The second stage is also the focus of this section.

Tender award criteria

"The award criteria constitute the basis on which a contracting authority chooses the best tender and awards a contract " (SIGMA, 2016, p. 2). Originally, the European Union allowed for the use of two award mechanisms. The contracting authorities could base the tender on *"the lowest-price criterion; or the most economically advantageous tender criterion, which meant applying criteria in addition to, or other than, price"* (SIGMA, 2016, p. 2).

Considering the ever-existing problems with the cost of healthcare, it is not surprising that the lowest-price criterion became a dominant method of healthcare tender evaluation. In addition to the perceived benefit of cutting costs, lowest price criterion is relatively easy to use as the only two factors that must be evaluated are compliance with the set criteria (stage 1), and the price of the offer (stage 2).

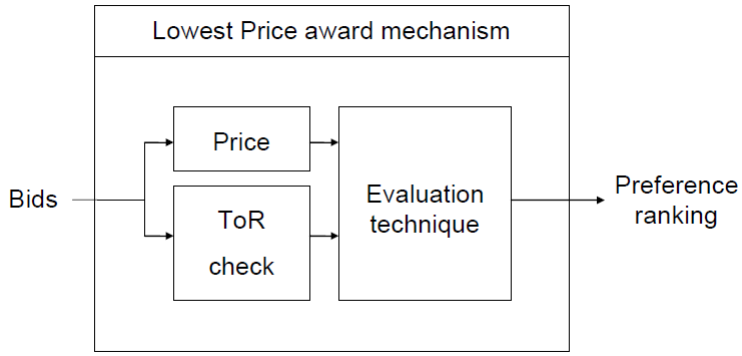

Figure 12: The lowest price award mechanism (Dreschler, 2009, p. 13)

Another argument for using low-cost award mechanism is the prevalence of the volume-based reimbursement in healthcare. If the providers (buyers) are rewarded based on single criterium – volume, they will tend to translate this into the first-stage criteria. Returning to the example of CT from previous section, healthcare provider reimbursed on volume would have a preference towards faster CT scanners at lowest possible price, thus maximizing the Volume/Cost ratio. By focusing on a single aspect of the device, suppliers are motivated to offer undifferentiated products and forced to compete solely on price. In such environment, cost-leadership is clearly the dominant strategy for the manufacturers.

In the long-term, the focus on price creates several problems. Firstly, from the strategic perspective, the industry where low cost represents the only form of competitive advantage becomes unsustainable. Product innovation stagnates, and manufacturers are trapped in a "race to the bottom". Since according to Porter (1980) low-cost producer position can only accommodate one firm, others will be struggling with low profitability. From the broader perspective, doctors who in principle aim to provide best possible care[27] may find themselves working with unsuitable equipment, hospitals may incur excessive maintenance costs over the lifetime of the equipment[28] and patient experience deteriorates (SIGMA, 2016). In effect price-only award mechanism has negative effect on all healthcare stakeholders and further entrenches focus on volume-cost dichotomy in healthcare delivery.

[27] in theory regardless of the incentive scheme
[28] since total cost of ownership was not considered by the award mechanism

Most Economically Advantageous Tender – MEAT

As of 2014 European Parliament (EP) changed the approach towards the public procurement with the 2014/24/EU Directive. Here, EC departed from use of the lowest-price criterion and fully transitioned towards the MEAT criterion. In view of EP *"all winning tenders should finally be chosen in accordance with what the individual contracting authority considers to be the economically best solution among those offered"* (European Parliament; Council of the European Union, 2014). The MEAT criterion allows for the use of three main award mechanisms – price-only, cost-only, and best price/quality ratio (SIGMA, 2016, p. 2).

It can be argued that MEAT does not in reality eliminate the use of lowest-price award mechanism, as procurers are still able to base their decision solely on the price. On the other hand, integration of this award mechanism under the scope of MEAT changes the context in which the lowest-price approach can be used. In accordance with the provision quoted above, decision should not be made on price as such, but rather on the overall economical contribution of the selected solution[29].

More important from the VBHC perspective are the other evaluation methods, which consider cost element and price/quality ratio. Here, the procuring authority has an option to introduce various qualitative and quantitative criteria, besides the price (Sciancalepore, et al., 2011). Regarding the cost-related criteria, procuring authorities are generally considering overall cost of the device throughout its life-cycle (life-cycle costs), which includes additional non-recurring costs (e.g. initial training of the personnel, end of life costs), and recurring operational costs (e.g. service and maintenance) (SIGMA, 2016). In terms of proxies for quality, the Article 67 of 2014/24/EU Directive mentions following factors:

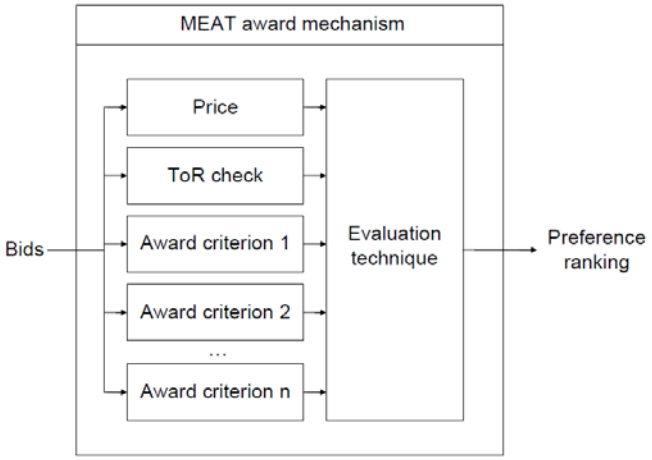

Figure 13: MEAT Award Mechanism (Dreschler, 2009, p. 14)

[29] in other terms, price-only criterion should be considered from the spirit rather than letter perspective of the directive

a) *quality, including technical merit, aesthetic and functional characteristics, accessibility, design for all users, social, environmental and innovative characteristics and trading and its conditions;*
b) *organization, qualification and experience of staff assigned to performing the contract, where the quality of the staff assigned can have a significant impact on the level of performance of the contract; or*
c) *after-sales service and technical assistance, delivery conditions such as delivery date, delivery process and delivery period or period of completion (*2014/24/EU).

In summary, the MEAT award mechanism gives procuring authorities a lot of discretion in the design of the award criteria. Nevertheless, the directive contains a provision stating that the selected criteria must be relevant to the objective of the procurement, must relate to the economic aspects of the procurement, and must be quantifiable (SIGMA, 2016). In addition, there must be a clear specification on the weighting of each criterium (i.e. contribution to the final score). Although there are many weighing mechanisms, EU imposes use of linear weighting (Sciancalepore, et al., 2011). Alternatively, procurers may indicate rank of importance for the criteria, where precise weighting is not applicable (SIGMA, 2016)

Finally, while it is easy to see the advantages of MEAT, there are some caveats which must be considered when using MEAT. Compared with the traditional tenders MEAT is a relatively complex exercise, which leaves ample room for manipulation. Depending on the evaluation formulas used, procurers can favorize certain bidders by assigning higher weighting on specific criteria (Sciancalepore, et al., 2011). Even without deliberate manipulation, tender outcome may change according to the formulas used (Stilger, et al., 2017). This sensitivity requires careful approach from the procurers and makes a case for pre-tender outcome simulation, which is rarely performed (Stilger, et al., 2017, p. 93).

3.7 Game Theory and Strategic management

The previous sections left one of the main criticisms of Porter's competitive positioning framework unaddressed. I am specifically referring to the Porter's static view of the industrial environment, where its discrete analysis followed by subsequent selection of strategic position within that environment allows for the creation of a relatively sustainable competitive advantage. The reality is often more complicated - especially in the health technology industry which can be defined as being oligopolistic.

It is improbable that any significant strategic decision made by one of the dominant firms will be isolated from the response of the competitors. On the contrary, competitors will react to the new situation in the market[30] with their own strategic changes, ultimately redefining whole industry. Eventually, rather than being formed by policy, health technology industry and healthcare as such will be formed by the interaction between dominant firms active in this industry. For this reason, I have decided to complement Porter's competitive positioning framework with game theory, application of which should facilitate understanding of the dynamics linked with a significant strategic disruption within healthtech industry.

The game theory has been introduced by John von Neumann and Oscar Morgenstern in their book *Theory of Games and Economic Behavior* (1944). Game theory provides a basis for the study of behavior in situations where the outcomes of the game for individual players are interdependent (Brandenburger & Nalebuff, 1995). Applied to the case of health technology companies, actions of each individual firm will influence whole market and outcomes for other firms and vice versa. Selecting a strategy and linking it to the outcomes for a firm is thus only possible after considering possible actions of the competitors.

Application of game theory in the context of strategic management is not very frequent. This is surprising, as there are many factors pointing to the good compatibility between the two disciplines. After all, game theory is a theory of strategy. As previously mentioned, business strategy of a firm is rarely isolated from the actions of the competitors, implying some level of existing interdependence between the actors. This assumption is generally valid, if there is an imperfect competition within the market, which is predominant situation in the real-world (Camerer, 1991).

If existence of interdependence between strategies of individual firms represents a perfect condition for exploitation of game theory in strategic management, the question is why the proliferation of game theory in this field remains so low. Camerer (1991) argues that one of the reasons is the perception of game theory as being static and outdated, a notion which he immediately refutes. There is however more important concern related to the application of game theory in strategic management – its strong foundation in economics.

[30] brought by VBHC and first mover

From the perspective of game theory, it is possible to convert strategic problems into purely macroeconomic problems and thus diminish importance of strategic decision-making processes developed in the field of strategic management (Saloner, 1991). Undoubtedly, this substitutive potential may result in certain apprehension towards game theory, but the main concern is often placed with the assumptions that must be made in the process of game theoric modelling.

Both Saloner (1991) and Camerer (1991) argue that game theory certainly has a function within the strategic management. If used as a way of thinking game theory can certainly contribute to strategic processes. Saloner (1991) argues that "*… literal interpretations of game-theoric models are largely irrelevant...[and]...the appropriate role for microeconomic-style modeling... and for game-theoretical modeling in particular, is not literal but rather is metaphorical*" (p. 121).

In this sense, game theory should be used as a guide to the logical processes where the situation involves (at least to some extent) rationally thinking actors whose fortunes are interdependent. It is exactly this role that the game theory partakes in this project. Rather than providing exact evaluation of healthtech firms' actions and their outcomes, game theory will serve as a tool for the modelling of the strategic environment and opportunities, that are presenting as a result of the VBHC framework.

Concepts of game theory

This project focuses on the application of a non-cooperative variant of game theory, which "*[models] and [analyzes] situations in which each player's optimal decisions depend on his beliefs or expectations about the play of his opponents*" (Fudenberg & Tirole, 1989, p. 261). In non-cooperative game theory (NCGT), actors do not form any kinds of coalitions between each other. Instead, they are competing within a given framework (a set of rules), where each player aims to maximize his own payoff (Fudenberg & Tirole, 1989). Since the payoffs of each player are interdependent, their maximization requires prediction of the opponent's move. Predictions are based on the assumption of rationality of all players – i.e. that each player always takes actions that maximize his payoff (Fudenberg & Tirole, 1989).

In NCGT, a game can be represented in an extensive (dynamic) and normal (matrix) form (Figure 14). Dynamic form contains information about the sequences of the decision-making process – the players do not make decisions simultaneously. In the normal form,

	C1	C2
R1	15, 5	4, 5
R2	9, 4	1, 1

Figure 14: Normal form

the potential strategic decisions are modeled in a matrix, with the assumption that players make decisions simultaneously. This form is used in this project, as the models will be used in the context of tendering, where the offers are submitted simultaneously.

The normal form shows the combinations of payoffs for two players in a form of a matrix, where by convention, payoffs for the row player (R) are listed first, and the column player second (C)[31]. The specific rows/columns (i.e. R1, R2, C1, C2) represent individual strategies of players. Depending on their payoffs, strategies can be classified into following categories:

a) **Best response** – a strategy giving player the largest payoff relative to the specific strategy of the opponent (Heap & Varoufakis, 1995, p. 43). In Figure 14, the best response of player C relative to player R's R2 strategy is C1 – as it gives player C largest payoff (C1=4 > C2 =1);
b) **Dominant strategy** – a strategy which represents a best response for a player, regardless of the opponent's strategy (Heap & Varoufakis, 1995, p. 44). In Figure 14, R1 is dominant strategy for player C, as it offers better payoffs for all opponent's strategies ((R1 = 15 > R2 = 9) for C1; (R1 = 4 > R2 = 1) for C2).
   The opposite of the dominant strategy is **dominated strategy** – in this case R2. In addition, strategies can be weakly or strictly dominant (dominated). **Strict form** occurs when one strategy (e.g. R1) dominates other (R2) for all the opponent's strategies (C1, C2). **Weakly dominant strategy** dominates alternative only for some of the opponent's strategies, e.g. Figure 14 C1 weakly dominates C2 as ((C1 = 5 = C2 = 5) for R1; (C1 = 9 > C2 = 1) for R2);
c) **Rationalizable strategies** – *"strategies that are left in a two-person game after the process of successive elimination of dominated strategies is completed* (Heap & Varoufakis, 1995, p. 48).

[31] for example, a strategic combination of (R1, C1) results in payoffs of 15 and 5 for the row and column player respectively.

Equilibrium

Equilibrium in game theory refers to an outcome of a game, where the players have rationalizable strategies to follow (Heap & Varoufakis, 1995). Equilibrium is easy to identify in cases where both players have dominant strategies i.e. each player is able to make strategic decision regardless of the opponent's action. In cases where only one player has a dominant strategy, game theory requires application of a common knowledge rationality (CKR) principle. This principle is illustrated in Figure 15, where the row player has a dominant strategy (R1), but the column player does not. In order to identify the outcome of the game, C must know that R is rational and will choose R1 (since it is his dominant strategy). C will then choose C2 based on first-order CKR[32] – reaching a **dominant strategy equilibrium** (Heap & Varoufakis, 1995).

	C1	C2
R1	15, 5	4, 9
R2	9, 5	1, 1

Figure 15: CKR Requirement

In cases where none of the players has dominant strategy, the identification of a stable strategic state requires different set of assumptions – that the players have some experience with the game, and that their beliefs are consistently aligned (Heap & Varoufakis, 1995). Consistent beliefs are defined by 2 features: "*players must be correct about their opponents' beliefs in some manner [and], second, players must believe their opponents are correct about [their own] beliefs*" (Kneeland, 2013, p. 14).

Assuming the validity of these criteria, it is possible (but not certain) to identify **Nash equilibrium** (equilibria) of the game, defined as "*a strategy selection such that no player can gain by playing differently, given the strategies of his opponents*" (Fudenberg & Tirole, 1989, p. 266). The mathematical equivalent of the statement is then: $u_i(a^*) \geq u_i(a_i, a^*_{-i})$; where u denotes utility (payoff), i player, a^* Nash equilibrium of the game, and (a_i, a^*_{-i}) a strategic combination where all players except i chose a^* (Fudenberg & Tirole, 1989, p. 266) (Osborne, 2004).

Critique of the game theory

Game theory has been widely criticized for the extreme dependency on the rationality assumptions. Indeed, the Nash equilibrium as a central concept in the game theory requires conditions which are improbable in real world. Empirical studies have proven

[32] in general, even-number CKR order implies "*R believes that C believes that…. R is instrumentally rational,*" whereas odd-number CKR implies "*R believes that C believes… that C is instrumentally rational*" (Heap & Varoufakis, 1995, p. 44)

that applicability of the Nash equilibrium, especially in new environments significantly decreases, with the consistent beliefs criterium being the most problematic aspect (Kneeland, 2013).

Still, the game theory represents a valuable tool for the modeling of social interactions. Colman (1995) argues, that criticism of the game theory with regards to the simplification of reality stems from the misunderstanding of its purpose. It is by design that the game theory reduces complexity of the real-world, so that the basic principles underlying social interactions are more visible (Colman, 1995). In the same way, game theoric modelling of the health technology companies' strategic positioning game in this project does not aim to prescribe or even predict actions for the individual companies. Instead it aims to highlight fundamental changes and new strategic opportunities of the VBHC.

4 Methodology, philosophy of science

This section will establish basic methodological and philosophical foundations of the paper. First section will outline theoretical approach, followed by the statement of the epistemological and ontological considerations. Final sections will define research strategy and design of the project.

4.1 Theory

In general, there are two main theoretical approaches which define the direction and structure of the research – deductive theory and inductive theory. The former defines a process where at the beginning researcher starts with a set of theories and expectations (Bryman & Bell, 2011). These are usually transformed into hypotheses which are subsequently being tested and at the end confirmed or rejected. At the end of the research the deductive process naturally transforms into an inductive process.

Induction (in the social research context) represents an opposite to the deduction i.e. it starts from the position of observation and ends with formulation of theories (Ritchie & Lewis, 2003). In essence, "*induction looks for patterns and associations derived from observations of the world; deduction generates propositions and hypotheses theoretically through a logically derived process*" (Ritchie & Lewis, 2003, p. 23).

Deductive approach is closely linked with Merton's view of the relationship between a theory and research, where the role of the former is to guide the latter, or in other words, where the theory drives design and organization of research (Bryman & Bell, 2011, p. 11). This is very much the case in this paper as the starting point for the research lies within

the theoretical account of VBHC, procurement and game-theoric modeling. Together, these "theories" provide a system of tools and expectations which essentially frame the whole research process. As a result, this research closely aligned with the deductive theory.

4.2 Epistemology

Another important aspect to consider is the epistemological approach of the research. Epistemology is concerned with the philosophy of knowledge, especially its nature and generation. Selection of epistemological approach defines what can be accepted as a knowledge, how is the knowledge created and how it can be communicated (Saunders, et al., 2016). The streams of thought in the epistemology are fragmented and evolving, but arguably the most robust stance is the positivism.

An epistemological foundation of this project - positivism – emphasizes "*the importance of imitating natural sciences*" (Bryman & Bell, 2011, p. 15) within social science. Positivism's core principle although contested among different authors relates to the application natural science research methods onto social phenomena. In this way, positivism rejects notion that human behavior is not subject to rules and regularities (as claimed by interpretivism) and maintains that it is possible to conduct objective social research through measurements and quantification (Ritchie & Lewis, 2003, p. 23). The objective of research is then to test theories (linked to deductivism) by study of regularities and formulate new laws and predictions which apply to the studied phenomena (Collins, 2010).

In this project, positivism materializes through deductivist approach and the analysis which is based on quantitative modelling. Consistent with positivism's main provisions, modeling is regarded as detached from the subjectivity of the researcher and it is assumed that the models account for and are able to (to some extent) predict behavior of social agents, in this case organizations. In effect, the research translates starting theories into testable hypotheses and through analysis and modeling verifies whether these theory-based hypotheses align with the reality. At the end, through the process of the induction, findings of the research are converted into new theories (or the original theories are defined as valid) (Bryman & Bell, 2011).

4.3 Ontology

Connected to the epistemology is the concept of ontology, which mainly focuses on: "*whether or not social reality exists independently of human conceptions and interpretations; whether there is a common, shared, social reality or just multiple*

context-specific realities; and whether or not social behaviour is governed by 'laws' that can be seen as immutable or generalizable" (Ritchie & Lewis, 2003, p. 11).

Ontological stream of thought related to the positivism is objectivism which considers social phenomena as objectively existing i.e. they are existing independently of the actors who are part of them. In this project, strategies and health systems are seen as existing independently of the firms and stakeholders within them and not as their product (Bryman & Bell, 2011) . As a result, this research aligns with the objectivist view of social phenomena.

4.4 Research strategy and design

In terms of research strategy and design, this paper represents a quantitative evaluation research on the strategies within diagnostic imaging market. Quantitative orientation is defined by a tendency of a research to focus on testing of hypotheses and evaluation of theories. In addition, it incorporates elements of scientific approaches mostly connected with the natural sciences (e.g. creation of numerical models) and views social reality as being external to the actors (Bryman & Bell, 2011, p. 27). In case of this research, quantitative research strategy is strongly implied from the configuration of epistemological, theoretical (deductive) and ontological positions and dependence on quantitative modeling similar to that being used in microeconomics.

Finally, the design is best described as an evaluation research as the core subject of the paper is an evaluation of an intervention (VBHC) on the feasibility of generic strategies for the diagnostic imaging equipment manufacturers. The analysis is structured as a quasi-experiment where the game theoric simulation of strategic configurations in the traditional healthcare is compared with the same simulation situated within value-based healthcare. Subsequently, the findings from each simulation are compared in order to evaluate impact of the studied intervention - VBHC (Bryman & Bell, 2011).

4.5 Data

To perform the analyses and construct models, a variety of data sources were used. The section 5.1 Diagnostic Imaging market is based on statistical databases namely OECD Health statistics and Statista as a source of market information and proliferation of diagnostic imaging technologies. Section 5.2 describing main competitors within diagnostic imaging market is primarily utilizing annual reports of the respective companies, and Gale Virtual Reference Library to gather other company information from the International Directory of Company Histories. Articles from the periodical Financial Times were used to a very limited extent in order to get an account of recent developments in the companies which were not accessible elsewhere.

Companies' diagnostic imaging product portfolio analysis is based on technical information provided by firms themselves, or in case they were unavailable from Imaging Technology News portal – a professional publication focusing on radiology, radiation oncology, women's health and nuclear medicine (Imaging Technology News, 2018). F

Finally, for the sections 5.3 Traditional procurement and 5.4 MEAT Tenering – VBP data were gathered from the database of the Office for Public Procurement of Slovak Republic, document database of Region Midtjylland, and from the Tenders Electronic Daily a supplement to the Official Journal of the European Union, containing a database of European tenders. Sources for other sections (e.g. Literature review, Theory) were books and academic/professional journals.

As a result, this research can be described as secondary analysis as no primary data were collected for the purpose of analysis.

5 Analysis

5.1 Diagnostic imaging market

The focus of this analysis is on the specific sub-segment of medical technology industry – diagnostic imaging. Diagnostic imaging (DI) represents a group of medical devices which are used to non-invasively examine internal anatomy of humans. Most commonly DI is used to diagnose medical conditions and physical injuries (e.g. tumors, fractures), or during image-guided interventions (image-guided surgery). In terms of products, DI market primarily focuses on sale of several imaging modalities, namely: computed tomography (CT), magnetic resonance imaging (MRI), ultrasonography, nuclear imaging, and conventional radiography (X-ray).

Despite the clinical adoption of some of the more advanced modalities (CT, MRI) dating only to 1970s, their current proliferation is immense. As of 2015, for the average OECD country, the proliferation reached 15.9 MRI and 25.7 CT units per million population (OECD, 2017). In fact, the widespread adoption of these two modalities created concerns about their overuse and their contribution to rising cost of healthcare (Hendee, et al., 2010). It is projected, that the demand for these technologies will continue growing in connection with the diagnostic requirements for the increasingly prevalent chronic diseases emanating from the aging demographics of developed countries and increasing access to healthcare in the developing countries (Grand View Research, 2017).

Currently, DI represents third biggest segment of the medical technology industry, with a global revenue generation of €33bn (10.1% share of the medical technology industry), projected to exceed €40bn by 2025 (Evaluate, 2017). The DI market is highly concentrated with the dominance of three medical technology firms: General Electric Healthcare (GE), Siemens Healthineers (Siemens), and Koninklijke Philips (Philips). Together, these firms account for 66% of the global DI market share (Evaluate, 2017b). Despite the pressure from other competitors – Canon Medical Systems (formerly Toshiba Medical), Fujifilm Healthcare, Carestream Health, Shimadzu Corporation – Siemens, GE and Philips are expected to continue in their dominance of the DI market with projected market shares of 25.8%, 21.4%, and 18.9% in 2022 respectively (Evaluate, 2017b).

DI market can thus be defined as oligopolistic competition where the *"firms compete with each other independently to achieve their objective (i.e. maximize profit) by controlling the quantity or the price of the supplied commodity"* (Niyato & Hossain, 2007, p. 17). Since the output quantity of the DI manufacturers is largely predefined by the demand of healthcare providers, the competition between the manufacturers is mostly based on price. The DI market can thus be modelled using the Bertrand competition model (performed later in the analysis).

5.2 Competitors

In order to be able to evaluate implied strategies of the DI manufacturers, and the potential impact of VBHC on these manufacturers, it is first necessary to analyze their basic features, financials, and product portfolios.

5.2.1 Philips

Of the three companies, Philips represents the only one which is completely focused on healthcare. Formerly an electronics conglomerate with a big consumer electronics division, Philips has been gradually streamlining its operations and strengthening its position in lighting and healthcare. The transformation was completed in 2017, when Philips spun-off its lighting division as a separate company.

By choosing to focus on healthcare, Philips essentially fixed its corporate strategy[33] i.e. where to compete. This signals a complete dedication to the selected industry and increases importance of the competitive (business) strategy, as the company cannot revert its decision. This is given by the fact that the decision to divest consumer electronics division[34] was primarily driven by Philips' decreasing ability of to compete in this industry (Van den Oever, 2013).

Still, there are undeniable advantages which stem from the divestment of the adjacent business lines. By streamlining its operations and dismantling of the conglomerate structure, Philips can benefit from lower overhead costs[35] and higher operational and strategic flexibility relative to the more organizationally complex competitors (Porter, 1989). This implies that Philips should be better equipped to cope with the changing landscape of healthcare and could potentially leverage first-mover advantage when positioning itself in the new environment.

Still, Philips is not yet exclusively focused on the medical technologies, as it retained a strong personal health division, accounting for 41% of its revenues[36] and 66.4% of its operating income[37] (Philips, 2018). While the retention of the consumer-focused business line is inconsistent with the overall framework of Philips' transformation, its linear revenue-generation potential may counterbalance volatility of the low-volume imaging equipment income. In addition, having an installed base of small health-related consumer devices can be leveraged for data collection through the internet of things. At the same time consumers will retain familiarity with the brand creating advantage for Philips' efforts to implement telemedicine.

Philips – Diagnostic Imaging Portfolio Analysis

In terms of the main DI modalities – MRI, CT, AMI[38], and DXR[39], responsible for 49% of sales in the diagnosis and treatment segment, Philips offers a relatively[40] small portfolio of products. The CT category is represented with only 6 categories of devices, with a focus on the high-end devices with IQon spectral CT and iCT Family. Middle-end

[33] not to be confused with business strategy
[34] of which Philips was at some point leader
[35] innate to the organizational complexity of conglomerates
[36] excluding legacy items
[37] excluding legacy items
[38] advanced molecular imaging e.g. positron emission tomography (PET)
[39] digital x-ray
[40] compared with GE and Siemens

consists of the Ingenuity family and low-end of the MX16Evo scanner. Considering the substitutability of the lower-end scanners, Philips' competitive advantage in the CT segment lies with its more advanced devices – especially IQon which represents a unique product relative to the competition.

MRI portfolio currently consists of a single family of devices – Ingenia. High-end is represented with the 3.0 Tesla devices and especially the Ingenia Elition. As a new product, the Ingenia Elition is directly developed as a response to the VBHC. The middle-end consists of 1.5 and 3.0 Tesla Ingenias and low-end is covered with the Ingenia Prodiva (1.5T). Similarly, as in case of CT, Philips is focused on the more advanced applications. This is illustrated by a relatively narrow portfolio of middle-range devices and a strong orientation towards the high-end device – Ingenia Elition. It is also important to note that the Ingenia family, at the time of its introduction was first on the MRI market to introduce digital signal acquisition and processing – which gradually becomes an industry standard.

The AMI category comprises of two scanners Vereos PET/CT and Ingenuity TF PET/CT. The former verifies Philips' orientation on differentiation in the high-end category, as Vereos represents the only fully digital PET/CT on the market. Finally, the general radiography segment consists of the advanced digital radiography/fluoroscopy solution (CombiDiagnost R90), high-quality digital radiography (DigitalDiagnost) and a low-cost solution (DuraDiagnost).

The analysis of the Philips DI portfolio indicates an orientation towards more advanced and expensive devices. Gaps in the CT portfolio, especially in the middle-range of scanners and a relatively narrow portfolio of the MRI devices has a potential to adversely affect unit sales volume. As mentioned before, Philips already has the lowest global market share - 18.9% compared with the 21.4% of GE and 25.8% of Siemens (Evaluate, 2017b).

5.2.2 GE Healthcare

Unlike Philips, GE Healthcare continues operations as a part of an industrial conglomerate. GE's entry into healthcare resembles that of the Philips, with early activities being related to X-ray equipment, followed by expansion into more advanced medical equipment (e.g. CT – 1975) (Grenland, 2015). GE gradually strengthened its position in healthcare industry and accelerated the expansion with several acquisitions. Most notable was the $9.5bn acquisition of Amersham plc, a biotechnological research firm, which resulted in the official formation of GE Healthcare in 2004 (Grenland, 2015).

Currently, GE Healthcare consists of three business lines – Healthcare Systems (DI), Life Sciences (successor of Amersham), and Healthcare Digital (General Electric, 2017).

in million $US	Revenues	Profit
Power	35,990	2,786
Renewable Energy	10,280	727
Oil & Gas	17,231	220
Aviation	27,375	6,642
Healthcare	19,116	3,448
Transportation	4,178	824
Lighting	1,987	93
Total industrial segment revenues	116,157	14,740

Figure 16: GE Industrial Segments (General Electric, 2017)

Following problems with the financial performance of the conglomerate, GE is in the process of realignment. Like Philips, GE aims to streamline its operations and focus on 3 key segments – healthcare, power, aviation - and digital technologies as a link between the three (Crooks, 2017). As illustrated in the Figure 16 healthcare segment is generating 16.5% of GE's industrial revenues, and 23.4% of its profits. With the profit margin of 18.0%, healthcare is the most profitable segment after aviation (24.3%) and transportation[41] (19.7%).

Clearly, healthcare as one of the best performing segments in the GE's portfolio should remain a priority in the strategic planning of GE. Nevertheless, as discussed before, multidivisional organizational structure, has disadvantages which could adversely affect GE Healthcare's competitiveness – disutility stemming from the organizational complexity, exposure to the performance of other divisions, competition for resources between the divisions, dependency on the central decision making, slow reactions to the changing conditions and negative effects on the divisional innovativeness (Sugheir, et al., 2012), (Porter, 1989).

GE Healthcare Diagnostic Imaging Portfolio Analysis

In CT segment GE offers devices grouped into two families. Revolution family covers CTs for advanced applications (such as cardiac scanning) and high-quality imaging. At the high-end, GE offers 3 spectral CTs – Revolution Frontier Revolution CT and Revolution HD. Despite a higher number of spectral devices, it is important to note that the technology used is inferior to that of the Philips IQon scanner, meaning that the Philips scanner is not entirely comparable to GE spectral devices in terms of clinical value

[41] which does not represent a focus area in GE's future strategy

offered. The Revolution family is complemented with 2 non-spectral scanners – Revolution EVO and ACT.

The second family of CTs – Optima is primarily focused on general radiology applications. Here, GE offers 3 scanners CT660, CT540 and CT520. The CT660 represents a mid-range with 64 detector rows, while the CT540 and CT520 are at the low-end with 24 detector rows. In terms of product positioning, GE's CT portfolio covers whole spectrum of applications, although it fails to offer devices with significant differentiation characteristics.

GE's MRI portfolio is similarly comprehensive. In the 1.5T category, the high-end comprises of Signa Artist and in 3.0T category of Signa Premier, Signa Architect and Discovery MR750w. The middle-end comprises of Sigma Explorer/Creator and Optima 450w in 1.5T category and Sigma Pioneer in the 3.0T category.

In AMI modality, GE has 4 devices with 2 advanced PET/CT scanners and 2 SPECT/CT scanners. The conventional radiography is represented with one device for simple, medium and advanced applications.

Overall, GE's covers a range of applications across all modalities. Compared with Philips, GE's portfolio is wider and better equipped to serve health providers requesting standard devices for standard clinical settings. Given that the less advanced DI equipment correlates with lower acquisition costs for buyers, the higher share of GE on the diagnostic market is to be expected. This is consistent with the market share – price equivalency suggested by Porter (1980).

5.2.3 Siemens Healthineers

In terms of corporate structure, Siemens strongly resembles GE, as it continues to function as an industrial conglomerate. Originally producing telegraphic systems, Siemens gradually diversified into other electronics and engineering industries (Highman, et al., 2012). Siemens' activities in healthcare started with the production of the first industrially manufactured x-ray tube in 1896 (GE in 1913, Philips in 1919) (Nascimento, 2014). Later, Siemens strengthened its position with the introduction of first real-time ultrasound (1966), production of CT, MRI and the creation of a first PET/CT scanner in 2002 (Reinhardt, 2006). In 2016 the healthcare division was renamed to Siemens Healthineers.

in million €	Revenues	Profit
Power and Gas	15,467	1,591
Energy Management	12,277	932
Building Technologies	6,523	784
Mobility	8,099	743
Digital Factory	11,378	2,135
Process Industries and Drives	8,876	440
Healthineers	13,789	2,490
Siemens Gamesa Renewable Energy	7,922	338
Total industrial segment revenues	84,331	9,453

Figure 17: Siemens Industrial Segments (Siemens, 2017)

As in the case of GE, healthcare at Siemens represents major source of revenues and income. In 2017, Healthineers generated 16.4% of Siemens' industrial revenues and 26.3% of its industrial profits. Combined with 18.1% profit margin, Healthineers was Siemens' most profitable segment.

Like its peers, Siemens is also in the process of restructuring with the aim of focusing on its industrial operations. As a result, Siemens listed 15% stake of the Healthineers in an IPO in 2017, while it intends to keep a majority stake in the company (McGee & Leahy, 2018) . Currently, Healthineers operate as partially autonomous company, with six business lines: Diagnostic Imaging, Laboratory Diagnostics, Advanced Therapies, Ultrasound, Point of Care Diagnostics, and Services (Siemens, 2017).

The listing of Siemens Healthineers combined with the continued majority ownership of the parent Siemens AG creates an interesting organizational situation for the healthcare company. On one hand Healthineers can benefit from lower dependence on the decision making of the parent company, which gives them ability to better react to changing conditions on the market and to have better control over the allocation of internal resources. In this regard, Healthineers partially emulate Philips. On the other hand, they are essentially a part of conglomerate which controls 85% of the shares, which means they are still to some extent subject to the decisions of Siemens AG, which comes with caveats described at the end of the GE Healthcare profile. Nevertheless, unlike in the case of GE, where the diversification is based on the less related segments (e.g. Oil & Gas, Aviation), Siemens' focus on technology and engineering may benefit Healthineers through better synergies between the segments. As a result, from the organizational perspective, Healthineers stand in the position between the GE Healthcare and Philips.

Siemens Healthineers Diagnostic Imaging Portfolio Analysis

For the CT modality, Siemens offers the most extensive portfolio in terms of models – 12 compared with 8 at GE and 6 at Philips. Spectral CT comprises of 3 high-end models aimed at advanced application – Somatom Force, Drive, and Definition Flash. Like GE, Siemens' spectral CTs relies on dual-source technology which is less advanced than

Philips' IQon technology. In the single-source category, Siemens offers high-end dual-energy Somatom Edge Plus, Somatom Definiton Edge, entry-level dual-energy Somatom Definition AS and productivity oriented Somatom Perspective. The mid-to-low range is represented with the Somatom go. platform with go.Top aimed at advanced applications (dual-energy), go.All general radiography, go.Up and go.Now at less-complex and cost-efficient applications. Finally, the low-end is represented with Somatom Scope. In effect, Siemens, with its CT portfolio covers whole spectrum of applications and price levels, directly competing with all GE's scanners and virtually all Philips scanners (except for IQon).

MRI modality is equally well represented with a total of 12 scanner models. Unlike the competitors, Siemens offers additional scanners besides the standard 1.5T and 3T models. On the absolute high-end is the 7T Magnetom Terra, which represents first commercially available clinical scanner of this strength. At 3T, Siemens offers high-end Magnetom Prisma for advanced applications, Magnetom Vida (high-quality general applications), Magnetom Skyra (wide-bore), and cost-efficiency oriented premium Magnetom Spectra. In 1.5T category Magnetom Sola (wide-bore) Amira and Aera (wide-bore) represent high-end devices for high-quality imaging, Magnetom Sempra and Avanto mid-range devices for conventional applications, and Magnetom Essenza cost-efficient entry-level solution. Finally, Siemens also produces 0.35T Magnetom C! open MR as absolute low-cost solution. Again, with a comprehensive MRI portfolio, Siemens competes at all application levels and price points. In addition, inclusion of 7T and 0.35T devices extends its range beyond that of the competitors, as such devices are not present in their (commercial) portfolios.

In AMI category, Siemens markets 4 PET/CT scanners (with 3 additional editions of the standard platforms), PET/MR scanner, and a range of SPECT/CT scanners. DXR modality comprises of several high-end digital systems, a low-cost digital system, and an ultra-low-cost analog system.

Comprehensiveness of Siemens' portfolio across all modalities correlates with its high market share on the DI market. It is not surprising, that being able to participate in more tenders as result of fulfilling demands of the purchaser will partially translate into a higher market share (especially through products without direct competition). Nevertheless, wide product portfolio can also represent a strategic challenge, as its management is more complex. Especially in the innovation-intensive industries (such as health technology) maintaining competitive portfolio requires constant investments into research (G.Cooper, et al., 1999).

In Siemens' case, maintenance of broad product portfolio across all modalities may become a challenge in the longer run. By offering high-end differentiated products, cost-efficient products, and middle-range products in all modalities, Siemens is strategically vulnerable to competitors focused on offering more innovative products (competitive advantage through differentiation), competitors with better cost structure (advantage through higher margins) and competitors outcompeting Siemens in specific modalities (focus) (Porter, 1980).

5.2.4 Evaluation of the portfolio analysis

Figure 18 illustrates relative positioning of the individual companies' CT and MRI portfolios in terms of quality[42]. For the CTs, the quality has been calculated as a function of number of detector rows, spatial resolution and spectral capabilities (see Appendix 1). For the MRI, quality has been calculated as a function of magnet strength, gradient and slew rate (Appendix 2). Subsequently, the scanners were ranked, and median position was calculated for each manufacturer. Finally, the positions were normalized on a scale between 10-110, where higher number indicates more advanced portfolio (quality) relative to the other manufacturers, and lower number indicates prevalence of less advanced (lower quality) devices, relative to the competitors.

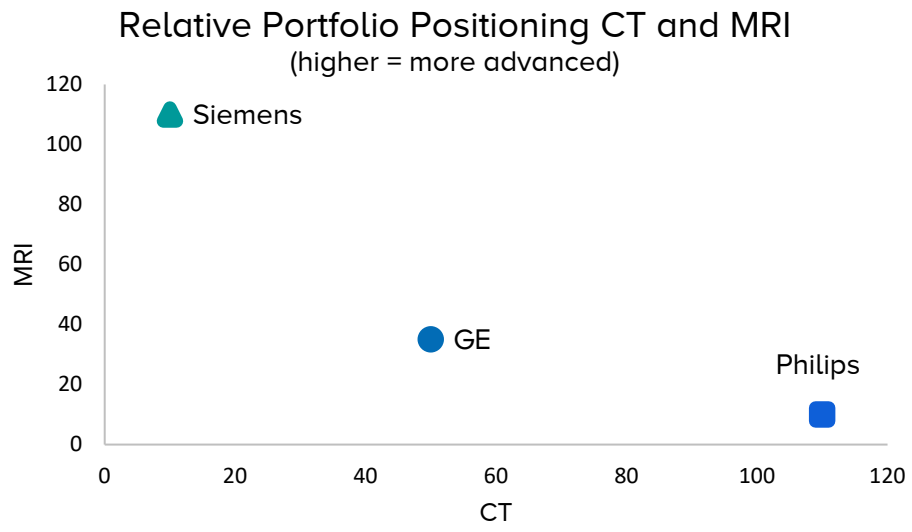

Figure 18: Relative Portfolio Positioning for CT and MRI

[42] here, quality is understood as a set of advanced features, i.e. higher quality corresponds to premium devices rather than reliability

On the y-axis (MRI) it is possible to see that positioning of the Siemens' MRI portfolio is relatively more oriented towards the premium end of the market, although a closer study (Appendix 2) shows that Siemens is well represented in all quality categories. GE represents a middle-to-low range manufacturer, with only one device in the premium segment (gradients above 80 mT/m). Finally, the core of Philips' portfolio is towards the lower-end, with some devices in the high-end. Nevertheless, its representation in the middle quality segment is the weakest.

On the x-axis (CT) the roles of Siemens and Philips are switched. In the CT segment, Philips' portfolio is biased towards the high-quality devices with 64+ detector rows and spatial resolution exceeding 24 lp/cm. GE, again covers the mid-to-low range with only one scanner in the premium segment (128+ detector rows). GE also most significant presence in the sub 32 rows segment. Siemens, despite having premium devices, has the core of its portfolio in the middle segment, between GE's mid-high and mid-low-quality devices (Appendix 1).

In conclusion, based on the portfolio analysis of the two most important modalities (MRI and CT), Siemens and Philips are pursuing leadership positions – Philips in CT with its focus on premium scanners and weak coverage of the middle and lower segments; and Siemens in MRI – best illustrated with the introduction of a commercial 7T scanner. GE on the other hand takes the position of a middle-range manufacturer in both modalities.

5.2.5 Corporate comparison

In terms of employees, Philips is the biggest firm followed by GE and Siemens. The same can be concluded based on the total revenues, although the contribution of Philips' Diagnosis & Treatment line (responsible for DI), is only €6.5bn – making Philips' DI activities the smallest of the three (Philips, 2018).

in million €	Royal Philips	GE Healthcare	Siemens Healthineers
Estimated Employees	73,951	52,000	48,000
Revenues	17,780	16,913	13,789
per Employee	0.240	0.325	0.287
Income	1,517	3,011	2,490
per Employee	0.021	0.058	0.052
as % of Revenues	8.53%	17.80%	18.06%
Research & Development	1,764	877	1,253
as % of Revenues	9.92%	5.18%	9.09%

Figure 19: Firm Comparison (General Electric, 2017), (Siemens, 2017), (Philips, 2018)

Important measure is the ability to convert revenues to income,

where Siemens is the leader[43], closely followed by GE. Philips on the other hand generates only 8.53% margin which is a significant underperformance relative to its peers. The same is then translated to the productivity per employee. GE generates highest revenues per employee (€325k), whereas the figures for Philips and Siemens are comparable (€240k and €287k respectively). The difference deepens with the analysis of income generation per employee, where Philips falls behind its peers with a figure of €21,000 compared with €58,000 at GE and 52,000€ at Siemens.

Last measure important from the strategic and VBHC perspective is the expenditure on the research and development. As mentioned above, innovation of products is crucial to retain competitiveness in the health technology, especially with the increasing emphasis on the quality of devices inherent to the VBHC. The R&D expenditure measure is largely consistent with the findings from the portfolio analysis, where Siemens and Philips occupied premium positions in MRI and CT segments (respectively), while GE took middle position. R&D expenditure was highest at Philips[44], closely followed by Siemens. GE's R&D expenditure was approximately half of that of the competitors – indicating more generic product portfolio (proved above). Still, GE as a part of the conglomerate may benefit from R&D activities of the other business lines. This is unlikely, however, as GE's other lines are not closely related to healthcare.

5.3 Traditional procurement

5.3.1 Disincentive to differentiation

From the analyses above, it is clear that Philips struggles to convert sales into income at a rate of its competitors, which is surprising considering its focus on health technologies. Undoubtedly, there are many factors which are affecting Philips' performance. The examination of the income statement, however shows that Philips has selling expenses twice the size of Siemens'. It is possible to hypothesize, that this is caused by the problematic positioning of Philips' product portfolio and the dominance of traditional procurement.

The portfolio analysis established Philips as manufacturer of advanced CTs and less advanced MRIs. Generally, there is a positive correlation between the differentiation (advanced scanners) and price, which is consistent with Porter's (1980) arguments.

[43] even after adjusting for Philips' consumer business line. In fact, the margin on the DI products is lower than the margin on the consumer products!
[44] both in absolute terms and relative to revenues

Translated to this case it means, that Philips is predisposed to leverage its competitive advantage in high-end CT segment, and aim to participate in tenders for advanced CTs. Naturally, the market for high-end devices is much lower than for the all-purpose scanners, implying lower volume of sales (despite higher margins of the high-end scanners). In addition, assuming pure price-orientation of the purchasers, and competition of Siemens and GE, the strong position of Philips in higher-price segment diminishes.

In addition, the higher-volume segments (medium/low range), where Philips lacks breadth of portfolio and where the devices are more generic (substitutable), there is going to be an extreme amount of pressure on the price. In other terms, without the possibility to differentiate products[45], the best approach is to have a range of devices with slightly different specifications – to better suit exact requirements of buyers – a strategy adopted by Siemens and GE. Philips, on the other hand competes with highly restricted portfolio of mid-to-low range CTs. In the traditional procurement conditions, gaps in the portfolio materialize in reduction of profit as modeled in Figure 20.

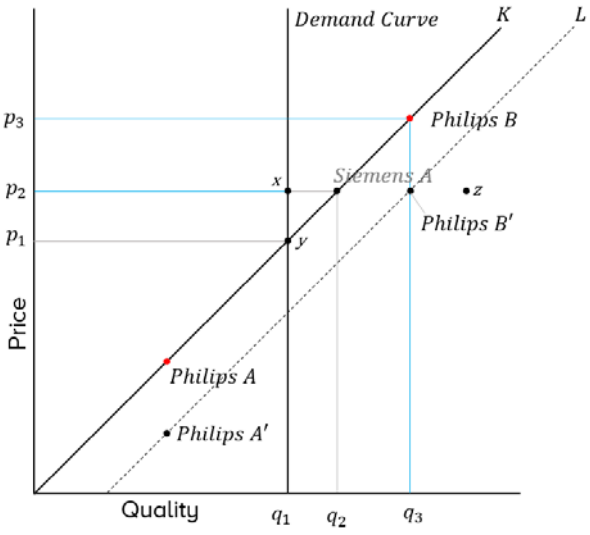

Figure 20: Inefficiency from smaller portfolio

In a situation where procurer requests scanner at quality q_1 in a traditional tender, Philips is unable to offer *Philips A* as it does not fulfill buyer's quality requirement. Instead, it has to offer much more advanced *Philips B* (normally priced at p_3, where $p_3 > p_1$) but must do so at a price matching that of the competition i.e p_2. As a result, winning this tender with *Philips B* would result in an implicit loss of p_3-p_2 > 0, whereas for Siemens, the win would result in no such loss[46].

The example above showed a situation where the products were vertically differentiated, but similarly, a situation may occur, where at point $[q_2, p_2]$ Siemens offers scanner *A* for general application, scanner *B* focused on cardiac application, and Philips only offers

[45] which is limited in the traditional procurement
[46] assuming certain level of purchaser's demand inelasticity.

scanner X for general scanning. In such case, even if *Philips X* was functionally equivalent[47] to *Siemens B,* Philips would still incur additional (selling/marketing) costs in compensating for the lack of explicit cardiac capabilities[48].

Returning to the issue of Philips' lower profitability, and its relationship to the strategic positioning, I formulate the following hypothesis: Since Philips is not able to leverage its strength in the premium CT segment, due to prevalence of traditional procurement, its profitability is lower than that of the competitors. Financial success in the commercial environment, defined purely by price and general functional parameters (i.e. traditional procurement), requires either low-cost provider strategy and a portfolio of generic products, or a large portfolio of products, where the manufacturer can more closely match requirements of the purchaser.

Substituted into Porter's (1980) competitive positioning theory – in a market where:

a) suppliers compete only through price;
b) demand is very limited and concentrated with few buyers;
c) buyers define and are sensitive only to the main functional characteristics of the products demanded (i.e. indifference to horizontal differentiation);
d) products are differentiated only by these generic characteristics (vertical differentiation), and;
e) the demand of individual buyers is heterogenous in terms of vertical differentiation,

the producers can only pursue strategy of maximizing vertical segmentation of product portfolio within the modality (e.g. MRI, CT). All other strategies – differentiation, cost leadership and focus are on their own infeasible.

Differentiation – illustrated with the point *z* in the Figure 20 – despite being qualitatively superior to *Siemens A,* in the traditional procurement the surplus quality is not rewarded and as a result point *z* lies on the same price level p_2 as the less differentiated products (i.e. *Siemens A*). If differentiation requires additional investments resulting in higher

[47] including cardiac scanning capabilities
[48] i.e. creating notion of functional equivalency of the two devices to prevent biases in the procurement design.

production cost of the product *z*, pursuing differentiation strategy in purely price sensitive market is unsustainable in the long run.

Cost leadership – in Figure 20 – if Philips pursued cost-leadership strategy (i.e. its price/quality curve would shift right from market clearing curve *K* to discrete curve *L* and assuming its production cost curve moves in the same direction and proportion*)*, it could move from point *Philips B* to *Philips B*' without implicit loss of p_3-p_2. Nevertheless, it would still suffer from overprovision of quality as both Philips *B* and *Philips B*' are at a quality q_3, whereas competitor offers product at a quality q_2, and purchaser demands quality q_1 (where $q_3 > q_2 > q_1$).

In this case, viable alternative to cost leadership is to offer more products on the same price/quality curve *K*, thus minimizing the difference between the quality demanded and quality offered, and the difference between possible market price and the actual competitive price of the device. In mathematical terms, cost leadership defined by minimization of total cost

$$C_{(d)} = FC_{(d)} + V_{(d)}$$

where $C_{(d)}$ represents total cost function of a producer, $FC_{(d)}$ total fixed costs, $V_{(d)}$ total variable costs, and d discrete price/quality curve, is equivalent to maximization of number of elements in the portfolio E

$$E = \{[q_1, p_1] \dots [q_n, p_n]\} \in x$$

where $[q_1, p_1] \dots [q_1, p_1]$ represent points on the market price/quality curve x. Therefore

$$minC_d \equiv \max E$$

for any d with slope identical to x, as the gain from the decrease of production cost (eventually sale price) is diminished by the implicit loss resulting from the provision of uncompensated excess quality.

Focus – as outlined in the portfolio analysis, focus on certain segments is not viable in price sensitive market because the additional benefits resulting from the manufacturer's specialization have no value in tenders based on generic functionality criteria. For example, producer of cardiac CTs would still face competition from producers of general purpose CTs if these offer basic functional equivalency to the dedicated cardiac CTs. Consequently, vertical portfolio differentiation would dominate vertical specialization by mechanisms of substitutability (indifference of buyer to horizontal differentiation) and cost (differentiation increases production/development cost (Porter, 1980)). In terms of focus/cost leadership strategy, producer with lower cost for specific products within a

modality would still face inefficiencies from restricted product portfolio (as illustrated above) making this strategy unsustainable from the long-term perspective. The only feasible focus strategy in cost sensitive market is inter-segmental focus (e.g. whole MRI segment or the whole CT segment) combined with portfolio maximization strategy.

To conclude, in a market where producers compete with horizontally homogenous but vertically differentiated products[49] through prices (Bertrand competition) the only valid strategy is to maximize the size of vertically differentiated portfolio. This way on an aggregate basis (firm level as opposed to product level) sellers can increase their competitiveness and at the same time limit implicit losses from offering excess quality (i.e. uncompensated quality above that required by the buyer). For this reason, it is expected, that the analysis of CT and MRI tenders in the next section will show that in the CT modality

5.3.2 Examination of a traditional healthcare tender

In this section I will outline functioning of the traditional (volume-based) procurement process on the example of procurement of 13 CT scanners that was recently carried out by the Ministry of Health of the Slovak Republic (MoH). The procurement was divided into 5 categories from the less advanced scanners (1) to more advanced scanners (5). I will focus on category 3.

The process starts with a call for bids which specifies administrative requirements regarding the background of competitors (e.g. not being insolvent) and defines the objective of the procurement. Most importantly, the call provides the technical specifications for the devices being procured, which must be fulfilled for the bid to considered. Non-compliance with any of the criteria results in disqualification from the tender. After clarification of all specifications through a dialogue between the potential participants and the procurer, the participants submit their bids.

In this case, the MoH received 4 bids for scanners from Philips, Siemens, GE and Toshiba. Toshiba was disqualified from the tender due to not fulfilling one criterium. The offers from other participants were as following:

[49] from the perspective of buyers, even though the products may be objectively heterogeneous

Siemens Somatom Definiton Edge	€1,233,995.73
Philips Brilliance iCT SP	€ 1,959,799.87
GE – Unknown Model	€1,693,700.00

Figure 21: Bids – price-based tender (Office for Public Procurement, 2018)

Interesting is the disparity between the prices of the bids, which exactly correspond to the positioning prediction made in the portfolio analysis, where Philips has the highest offer, GE is in the middle and Siemens has the lowest price. From the table in the Appendix 1, it is apparent that Philips iCT SP and Siemens Somatom Definition Edge are direct competitors in the same quality segment – implying equivalency in their pricing.

Nevertheless, there is an important distinction between the age and the original positioning of the two scanners. iCT has been introduced at the end of 2007 as a high-end innovative scanning platform[50] (Frost & Sullivan, 2009). Definition Edge, on the other hand, has been introduced in 2012 and has not been positioned as premium device (NICE, 2016).

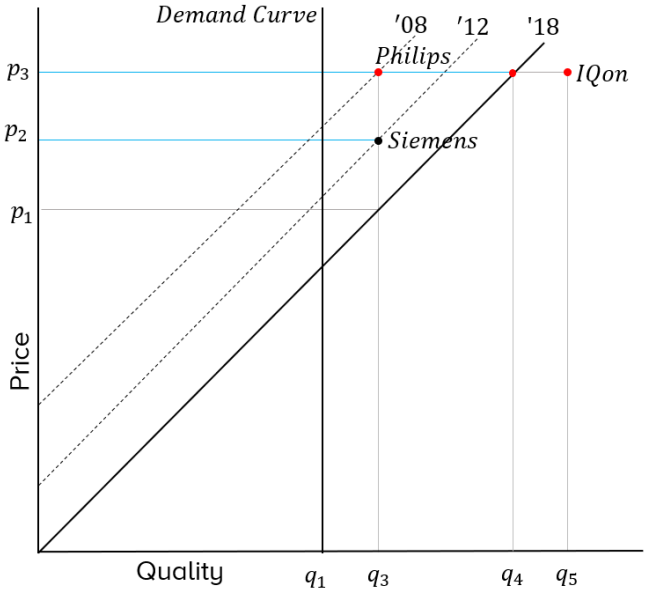

Figure 22: Price / quality relationship in price-based market

Returning to the theory about the portfolio density from the previous section, it is possible to model the situation as in Figure 22. Philips' positioning for iCT in 2008 has been at p_3, which is above the current price p_1 equivalent to that level of quality. Siemens' newer scanner, however has been originally designed to be positioned much closer to p_1 with the 2012 equivalent price of p_2. Philips is thus facing disadvantage of being innovator – since it must recoup higher development costs of premium (in Porter's (1980) competitive positioning terms *differentiated)* scanner.

[50] Representing Philips' flagship model until the introduction of IQon

Depreciation of innovations is a generally known principle, and under normal market conditions – assumed by Porter (1980) innovators (differentiated firms) can compensate for the additional cost by premium prices. Theoretically, the premium should also cover the trade-off in the form of lower market share. These mechanisms, however, are not present in the traditional healthcare. With the pure focus on cost element, differentiation becomes unsustainable strategy, as the differentiated manufacturers cannot leverage their innovativeness throughout the life cycle of the product. Instead it is more advantageous to enter (especially premium) price segments later, taking advantage of technological depreciation. The logic of such approach is further strengthened, as strongly budget-constrained healthcare providers have no incentive to act as early adopters of new technologies. This links back to the issue of volume-based reimbursement model of traditional healthcare, where providers are not rewarded for the quality of care.

Figure 22 contains an additional point *IQon* to explicitly illustrate infeasibility of differentiation in the environment of standard procurement. In the same way as iCT in 2008, IQon represents innovation leadership within spectral CT imaging. In terms of quality (x-axis) IQon takes the rightmost position at q_5, however it is placed below the '18 price/quality curve. Since the theoretical highest quality (with the presence of competition) which the buyer can request is q_4, Philips' decision to ask for a price above p_3 would ultimately lead to losing the tenders. The only situation where Philips could offer price corresponding to q_5 as given by price/quality curve would be if purchaser specifically requested scanner with technology of IQon. This is however unlikely in the traditional procurement, as such specification would raise suspicions regarding the tender fraud, as IQon would be the only qualified scanner[51].

The problem of disincentivizing of innovation in traditional procurement is further exacerbated by complementing standard bidding procedure with subsequent electronic auctions, as was the case in the Slovak tender. The initially submitted prices (Figure 21)

[51] while a situation where procurement has only one qualified competitor is possible, the problem in this case would mostly stem from the fact, that functionally IQon can be substituted with other spectral CTs, albeit technically inferior.

thus have merely a signaling value[52]. Following the initial offers and evaluation of compliance with the terms of reference, successful candidates enter the first round of electronic auction (Sičáková-Beblavá, et al., 2011). After ranking their bids in terms of price the 2 bidders with the lowest prices were selected to proceed into the second round of electronic auction[53]. The outcome of the second electronic auction was:

Siemens: €804,091.20 – a reduction of €420,904.53 compared with the initial bid;

Philips: €867,838.00 – a reduction of €1,091,961.87 compared with the initial bid.

This tender precisely illustrates the concept of implicit loss introduced in above. While the exact reason for Philips' initial listing of the €1.9m price is unknown, there is a basis for such decision. If the motivation was to purposefully raise the base price to leave a room for a decrease in the electronic auction, then it is questionable why Siemens and GE didn't engage in a similar tactic. Rather than manipulation, the examination of bids in the other qualitative categories of the overall tender indicates that the €1.9m figure was a reasonable quote. In the 3 other tender categories where Philips participated, their bids were closer to the competition. Since there is no penalty for high initial bids, if Philips was engaged in a manipulation, it would have been observed also in the other categories.

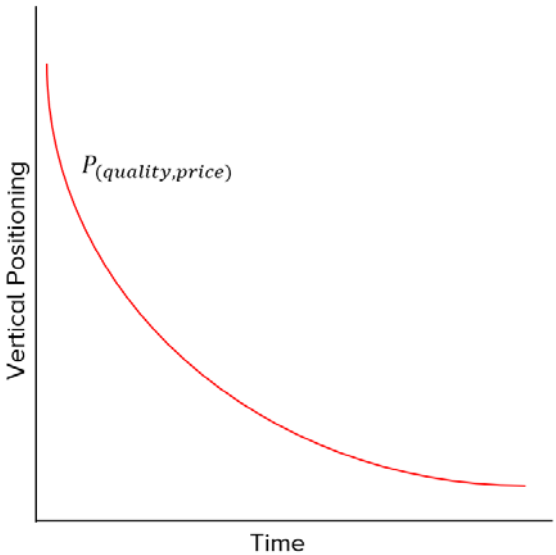

Figure 23: Change of positioning over time

The case of Slovak price-only based CT tender proves the hypotheses put forward in the previous section. Differentiation in cost-oriented healthcare is a dominated strategy. The analysis of the tender, however introduced a new dimension to the postulate on the importance of the vertical portfolio segmentation. The vertical positioning P of the products, defined as a function of price and quality changes over time t, as described in Figure 23. Thus $P_t \neq P_{t+1}$. This implies that the

[52] which is beneficial from the perspective of this analysis
[53] GE was excluded in the first round, Philps and Siemens proceeded to the second round.

feasibility of the differentiation strategy depends on the ability to collect pricing premiums early in the life cycle of the products. This is especially important for health technology industry, where the main differentiating factor is innovativeness (quality) of the products, although the relationship is valid also for the other differentiating features[54], albeit the depreciation occurs at different speed.

Still there is an important aspect to consider. As outlined in the theory section, in real-world, companies can use hybrid strategies i.e. a combination of multiple generic strategies (Pertusa-Ortega, et al., 2009). In this sense, it could be possible operationalize differentiation strategy if it is accompanied by cost leadership at the same time. In this way, a firm can operate on a price/quality curve that is below that of the market (i.e. curve *L* in Figure 20). There is however a pertaining problem with such strategy in traditional healthcare i.e. that the differentiated cost leader will never be able to monetize the differentiating factors of his products. So, while it may be theoretically possible to include differentiation as a part of business strategy, the entirety of competitive advantage would fall on the ability to manufacture at a lower cost.

5.3.3 Game-theoric view of the traditional procurement

The infeasibility of strategy of differentiation in the traditional healthcare (defined by volume-based reimbursement and price-based procurement) can be perfectly modeled using the game-theoric approach.

The following game represents a simplified version of the price-only tender analyzed in the previous section. The number of competitors is reduced to 2 and each competitor can choose from two strategies – differentiation (*D)* or no differentiation (*N)*. Consistent with the assumptions laid down by Porter (1980), the differentiation is linked to higher

[54] e.g. design gets antiquated or copied, quality customer service becomes standard as more consumers demand it. Essentially, every differentiating factor, if responsible for above-average returns, would be emulated by competitors to the point where the differentiating factor becomes commonplace.

profitability, but consistent with the idea of price-only procurement, it has no impact on the decisions made by procuring authority. In this example, the term differentiation will relate specifically to product innovations.

Here, it can be argued that if differentiation does not bear any effect on the willingness of buyers to pay, there is no ground for assuming higher profit margins for differentiated products (especially in the absence of non-differentiated competitors). The assumption of higher profitability[55] is thus based purely on the principles of aggregate demand and supply, where if firm pursues differentiation strategy, it decreases total supply of devices[56], thus weakening the position of buyers and increasing the attractiveness (i.e. profitability) of the industry[57].

Finally, it is assumed that both firms (players) are rational and that their respective production costs are identical for both strategies *D* and *N*[58]. Finally, the buyers are indifferent regarding the portfolios of two producers as all of them fulfill their required criteria. We can model the situation as following:

	PD	PN
SD	10,10	0,15
SN	15,0	5,5

Figure 24: Payoff matrix 1

Figure 24 contains a matrix with the possible strategic combinations of two players S and P. The numbers represent ordinal payoffs to the participants over a set of repeated games, where the players follow certain strategies – SD a differentiation strategy of player S; SN a non-differentiation strategy of player S; PD a differentiation strategy of player P; and PN a non-differentiation strategy of player P. Each combination represents a strategic profile (Watson, 2008).

Strategic profile [SD, PD] defines a situation where both players decide to pursue strategy of differentiation. Although the buyers are indifferent to the differentiating factors, the producers must cover development costs of the innovations which pushes

[55] on a per unit basis
[56] this is given as the increasing supply translates to higher market share, and increasing market share reduces uniqueness (differentiation) of the product, i.e. differentiation is always relative
[57] naturally, the side effect is the higher profitability of all competitors
[58] understand as Philips' D strategy production cost equals Siemens' D strategy production cost

costs (and prices upwards). Nevertheless, the companies must compensate higher riskiness of the differentiation strategy with higher returns.

Strategic profiles [SN, PD] and [SD, PN] represent a situation where one of the competitors decides to pursue non-differentiation strategy, while the other does not. In an environment where price is the only deciding factor for the buyers, pursuing strategy of non-differentiation allows non-differentiated manufacturer to reduce costs and achieve competitive advantage. This way, the lower-cost producer can undercut differentiated producer in tenders and maximize the market share.

The last strategic profile [SN, PN] show a situation where both firms decide to adopt no-differentiation strategy. Essentially, the manufacturers internalize cost-oriented characteristic of their environment and focus on provision of generic products resulting in overall lower profitability for all market participants (Porter, 1980).

For player P, the best response to strategy to SD is non-differentiation ((PN = 15 > PD = 10) for SD), whereas for the strategy SN, the best response strategy of P is differentiation ((PD = 4 > PN = 2) for SN). The same situation applies to the player S, where SD dominates SN for PN, and SD is dominated by SN for PD. This means that neither of the players has a dominant strategy. As a result, definition of an equilibrium state is not possible by only using the common knowledge rationality principle (CKR).

As neither P nor S have dominant strategy, and both players have to move simultaneously, they have to make assumptions about the possible movement of the opponent in order to define their own strategy. The state when none of the parties has dominant strategy requires application of the consistently aligned beliefs (CAB) principle, where the" *players must be correct about their opponents' beliefs in some manner [and], second, players must believe their opponents are correct about [their own] beliefs*" (Kneeland, 2013, p. 14).

The only position where the CAB applies is the strategic space [SN, PN], where both competitors select non-differentiating strategy with the lowest possible payoff of 5. As a result, this alignment represents Nash equilibrium of this game (Heap & Varoufakis, 1995). The stability of this state is granted by the fact that none of the players can make himself better off by changing his strategy, given that the opponent does not change his. As long as one player remains at strategy xN, the opponent can always move only to state where the payoff is 0.

It is also possible to model the game differently. In this case, it is assumed that the firm P is using differentiation strategy and the firm S is using cost leadership strategy. As a result, firm P's production costs $C_{(P)}$ are higher than the production costs of firm S - $C_{(S)}$

$$C_{(P)} = FC_{(P)} + V_{(P)} > C_S = FC_{(S)} + V_{(S)}$$

Firm still compete with each under conditions of lowest-price tender award criterium and buyers are still indifferent to the higher quality provided by the differentiated producer. In this game, firms cannot change their business strategy (i.e. differentiation or cost leadership) but they are able to change pricing of their products – with strategy *H* being bidding high prices and strategy *L* bidding low prices (relative to each other, not competitors). As such, this game better approximates reality. The payoff matrix is approximated as in Figure 25, where the numbers represent ordinal payoffs of the two players over a set of repeated games:

	PH	PL
SH	10,8	0,8
SL	11,0	6,5

Figure 25: Payoff matrix 2

Strategic profile [SH, PH] represents a situation where both firm follow high bidding strategy. Their payoffs are relatively high (compared to other strategic profiles), but unlike in the previous game, the payoff for differentiated firm (P) is lower than that for the non-differentiated firm (S). This is given by the higher cost function of the differentiated firm. Assuming that both firms are bidding the same price, the profit margin for cost-leading firm is consequentially higher as $P_S - C_S > P_P - C_P$ for $P_S = P_P$; $C_S < C_P$ (where C_x is total cost and P_x bid price for firm *x*). Since the bid prices are the same for both firms, probability of winning tenders for each of them is p=0.5.

Strategic profile [SH, PL] shows a situation where the differentiated firm (P) follows low bidding strategy while the cost-leading firm (S) follows high bidding strategy. The payoff for the firm S is thus zero as $P_S > P_P$ i.e. S is losing tenders. Payoff for the P is 8 as even though the bid price is lower than in [SH, PH], the decrease in $P_P - C_D$ is being compensated with higher win ratio – 100%.

In a strategic profile [SL, PH] the bidding strategies of the firms are opposite than in the [SH, PL]. Payoffs for the firm S are higher than in [SH, PH] as S can bid relatively high, since P is following high bidding strategy, and still secure win in 100% of the tenders.

Finally, in the [SL, PL] both firms get relatively low payoffs as both are pursuing low bidding strategy. The differentiated firm, however is relatively worse-off than the cost-leading firm, which is expected as $P_S - C_S > P_P - C_P$ for $P_S = P_P$; $C_S < C_P$ (i.e. same as in the [SH, PH]).

In this game, firm S has a dominant strategy of low bidding as it represents a best response to all strategies of firm P ((SL = 11 > SH = 10) for PH; (SL = 6 > SH = 10) for PH). The Nash equilibrium of the game can thus be established through the first-order CKR, i.e. P believes that S will always choose *L* (dominant strategy) therefore P will choose *L* (best response) (Heap & Varoufakis, 1995). Important observation here is that the equilibrium is at a point where both players are relatively worse-off (compared with [SH, PH]). If the players agreed to follow high bidding strategy[59] this equilibrium would be unstable, as both players would have an incentive to change their strategy to low bidding.

For the differentiated producer, there are severe consequences of settling in a Nash equilibrium position of [SL, PL]. Given the recurring characteristic of the relatively[60] low payoff, the differentiated firm will in long-term face lower profitability than the competitor. In essence, differentiation strategy will in the cost-oriented market represent a liability, whereas cost-leadership strategy will create competitive advantage for the firm pursuing it.

Finally, from the perspective of the industry (in this case represented by firms S and P), strictly price-based competition adversely affects all industry participants as it creates strong downward pressure on its overall profitability. Using the terminology of Porter's (1980) five forces framework – price-only tenders increase bargaining power of buyers, increase intensity of rivalry between the competitors, and by disincentivizing product innovation lower entry barriers for new competitors[61].

[59] which would in reality constitute a breach of the competition law by forming a cartel
[60] compared to the cost-leading firm S
[61] as the products are more generic

5.4 MEAT Tendering – VBP

MEAT tendering has been identified as a key driver with the potential to support transformation toward the VBHC (Nordic Innovation, 2017). Indeed, as described in the theoretical section on MEAT tendering, procurers can use a number of criteria to specify requirements of the device being procured. Ideally, these should help healthcare providers with procuring devices and technologies, which contribute towards the maximization of the value in healthcare (e.g. quality of patient outcomes / cost).

Implementation of the value concept into a healthcare setting has so far been very difficult. Despite Porter & Teisberg's (2006) straightforward definition, value tends to vary between the functional units of healthcare provider (Prada, 2016). It is therefore not easy to design procurement process, which maximizes value generating potential of the providers. Nonetheless, it is clear that procurement based on price-only criterium fails to deliver optimal value (Prada, 2016).

True value-based procurement in healthcare is still in very early stages, which may explain lack of empirical studies on its effectiveness. As a result, examples of value-based procurement initiatives are mostly restricted to a limited number of high-profile cases. One such example is the 2014 procurement of the diagnostic imaging services by Karolinska University Hospital, where the criteria were strongly based on the supplier's research & development and innovation capabilities. Out of the five initial participants only three fulfilled the criteria, with Philips being the final winner (Gerecke, et al., 2015).

Cases like the Karolinska University Hospital tender are very unique and specific, and while they may serve as a best-practice example, emulation of similar procurement design is difficult with smaller hospitals (clinics), whose interests are far from those of the major research institute. For this reason, it is more useful[62] to identify elements of the value-based procurement that are applicable in a larger scale.

The key principles of value-based procurement in healthcare can be reduced to four layers – outcomes, costs, other benefits for key stakeholders, and broader impact on

[62] also for the study of VBHC impact on the strategies of healthcare suppliers

society (Nordic Innovation, 2017, p. 15). Again, while these layers are definitely representative of the Porter and Teisberg's (2006) VBHC, identifying specific measures for each layer would result in unnecessary departure from the core objective of this study. For this reason, the four layers are further reduced into two key components of the value-based procurement - price and quality[63]. Since MEAT principle relies on the same concept of price/quality ratio, it represents a good model for the study of implications of VBHC / VBP on the strategic options of the health technology companies.

5.4.1 Exemplary structure of the MEAT tender

MEAT tenders can have many forms but for the purpose of this study it is only important to define basic effect of the inclusion of quality component into the tender award criteria. The following case will illustrate a procurement of a CT from the previous example, with the expansion of criteria to those listed in Figure 26:

Awarding of tender will be based upon the following:

- Image quality (large and small patients)
- Price
- Functionality
- Dose reduction
- Software capabilities
- Value added benefits
- Vendor performance
- Upgradability
- Patient comfort and safety
- Service and support
- Clinical applications
- Coronary Angiography (dose/heart rate, image quality, Ease of processing)

Figure 26: Tender evaluation criteria (Western Health, 2008, p. 4)

It is likely, that many of the criteria for VBHC will be difficult to precisely measure. In Figure 26 for example, factors such as patient comfort and safety or vendor performance are highly subjective. In such case the 2014/24/EU Directive guides towards the use of a ranking mechanism, where unmeasurable criteria are ranked on the basis of relative compliance with the requested specifications, or the procurer can use own scoring mechanism like the one in Figure 27. Finally, the procurer needs to specify other aspects of the tender evaluation such as price and quality weights.

[63] which closely resembles quality of patient outcomes and cost in Porter and Teisberg (2006)

Score	Description
0 points	Best possible solution or fulfillment of requirement
1 point	Excellent solution or fulfillment of requirement
2 points	Very satisfactory solution or fulfillment of requirement
3 points	Above adequate solution or fulfillment of requirement
4 points	Satisfactory, adequate solution or fulfillment of requirement
5 points	Just below adequate solution or fulfillment of requirement
6 points	Less than adequate solution or fulfillment of requirement
7 points	Substantial below adequate solution or fulfillment of requirement
8 points	Only fulfills mandatory requirements

Figure 27: Quality evaluation scale (Region Midtjylland, 2016, p. 9)

For this model, the weight of price is 50% and the weight of quality is 50%. Tender is evaluated based on the lowest evaluation price where the quality points are converted into monetary equivalent, and the final evaluation price is calculated as:

$$EP_1 = w_P B_1 + w_Q S_1 \frac{\frac{1}{n}\sum_{i=1}^{n} B_i}{S_{max}}$$

where EP_1 is evaluation price, w_P weight of price component, w_Q weight of the quality component bid (price), B_1 price (bid), S_1 quality score for bidder 1 of n in the tender, and S_{max} the highest possible score.

Using the prices from the previously analyzed traditional tender, and assuming that Siemens, Philips, and GE received quality scores of 4, 0, and 2 respectively, the outcome of the MEAT tender would be as in Figure 28.

in €	Siemens	Philips	GE
Bid	1,233,995.73	1,959,799.87	1,693,700.00
Quality Score	4 points	0 points	2 points
conversion	814,582.60	-	407,291.30
Price (50%)	616,997.87	979,899.94	846,850.00
Qality (50%)	407,291.30	-	203,645.65
Evaluation Price	1,024,289.17	979,899.94	1,050,495.65

Figure 28: Simulation of a MEAT tender

Introduction of the quality component connected with the move towards the VBP in theory opens possibility to remain competitive even at a higher price point, provided that the increase in price relative to the lowest bid is compensated with the equivalent increase in quality of the more expensive product. In terms of the model in Figure 20 (p.53) Philips B remains competitive with Siemens A if $w_P(p_3 - p_2) \leq w_Q(q_3 - q_2)$.

5.4.2 Game-theoric view of the value-based procurement

As outlined in the previous section, MEAT tendering offers opportunity to compete even with higher prices if the extra cost is justified with higher quality. In this way, it should be possible for health technology companies to invest in innovations and value-enhancing features of the products while achieving above-average returns (Porter & Teisberg, 2006). The feasibility of the differentiation strategy will be examined in this section.

The first model represents a game with two players *S* and *P* where each can choose either differentiation strategy *D* (i.e. high value) or non-differentiation strategy *N* (i.e. low value). The cost structure for both firms is identical for the same strategies:

$$C_{(SD)} = FC_{(SD)} + V_{(SD)} = C_{(PD)} = FC_{(PD)} + V_{(PD)}$$

$$C_{(SN)} = FC_{(SN)} + V_{(SN)} = C_{(PN)} = FC_{(PN)} + V_{(PN)}$$

Both firms are rational, and buyers are sensitive to the differentiation (i.e. higher value) of the products and their objective is to maximize value procured, defined as a ratio of price and quality. The payoff matrix (indicating ordinal payoffs for the firms) of this market is following:

	PD	PN
SD	10,10	9,9
SN	9,9	5,5

Figure 29:Payoff matrix 3

Immediately apparent distinction from the price-based payoff matrix is that in all strategic profiles, the payoffs for both players are matched. This indicates extremely high level of interrelation between the individual strategic decisions of the players, and points to the tendency of players to align their interests (without explicit cooperation) in pursuing highest aggregate payoff (Osborne, 2004).

This state is present in a strategic profile [SD, PD], where both players pursue differentiation strategy. Since buyers are sensitive to quality, both producers are able to provide high value products at higher prices. Unlike in the cost-based market, innovation and maximization of quality is rewarded. In addition, the differentiation strategies of two players do not have to interfere with each other i.e. each player can base the strategy on non-identical factors (Porter, 1980). For this reason, the higher returns related to this strategic configuration is sustainable in the long-run.

The strategic profiles [SD, PN] and [SN, PD] offer slightly lower ordinal payoffs than the [SD, PD], although whether this would be the case in real-world is questionable. On one

hand, since one of the players chooses non-differentiating strategy, a certain level of price competition may result in the lowering of the equilibrium bidding price (i.e. level at which the buyer is indifferent between low-cost/low-quality and high-cost/high-quality). Regardless of whether the payoffs [SD, PN] / [SN, PD] should be equal to payoffs in [SD, PD], the core principle observed is that the competitors are able to remain relatively profitable despite incongruence of their strategies. This was not possible in the price-only model, where the non-differentiated firm completely dominated differentiated firm.

Finally, the profile where both firms have non-differentiated strategies [SN, PN] brings lowest payoffs to all competitors. Essentially, it represents a return to price-only tendering as the firms compete purely on price and not quality. At the same time this configuration minimizes quality of patient outcomes component of the Porter and Teisberg's (2006) value in healthcare definition.

In this game, the dominant strategy for both players is differentiation as it is the best response regardless of the opponent's decision. Identification of Nash equilibrium at [SD, PD] thus requires zero-order CKR. From the perspective of VBHC such outcome would be ideal as it maximizes quality of the patient outcomes (Porter & Teisberg, 2006).

The final game models a situation where firm S is a cost-leader and firm P is a differentiated producer subject to production cost curves $C_{(S)}$ and $C_{(P)}$ respectively, and where:

$$C_{(P)} = FC_{(P)} + V_{(P)} > C_{(S)} = FC_{(S)} + V_{(S)}$$

Firms can select from 2 strategies – high bids (prices) *H* and low-bids (prices) *L* assuming no change in the quality of the products offered. Therefore, at the same price P_x the value provided by producer S (v_S) lower than the value provided by producer P (v_P) i.e. $P_x \Rightarrow v_P > v_S$. The payoff matrix is defined as following:

	PH	PL
SH	0,13	0,7
SL	6,6	5,0

Figure 30: Payoff matrix 4

Introduction of the cost criteria significantly changes payoffs for the firms. Unlike in the previous game, the outcomes of the players are not matched and in three out of four strategic combinations, one of the players is unable to compete.

First such case is the profile [SH, PH]. Here, the differentiated firm obtains highest possible payoff as it can leverage its differentiation. A buyer who is trying to maximize the value of the procurement has no incentive to award tender to a firm with a high-

priced bid and generic product, subject to the $P_x \Rightarrow v_P > v_S$ provision. Similarly, cost-leading producer S cannot justify high bids when the differentiated firm follows low-price strategy. Despite lowering its payoff, P is still able to capture whole market since it provides superior value to health providers. Final case of a complete dominance of one firm is the [SL, PL], where the differentiated firm is unable to compete with the low-price bids of the cost-leader[64].

The last strategic profile [SL, PH] offers equal payoffs to both players. This is given by the fact that each firm can follow a pricing strategy that is consistent with their business strategy (i.e. differentiation / cost leadership). The competitors are able to bid different prices because of the equivalency in the value for the procurer $v_P = v_S$. This position also represents Nash equilibrium as no player can increase his payoff by changing strategy, while the sticks to the original strategy. As in the previous case, determination of the equilibrium required zero-order CKR as both players have a dominant strategy, independent of the actions of opponent (i.e. strategy L for firm S and strategy H for firm P).

The outcome of this game indicates that the move towards VBHC through VBP can really have a positive impact on the (business) strategic flexibility of the firm in health technology segment. While the games simulating traditional procurement, process were dominated by the low-cost non-differentiation strategy (adversely affecting all stakeholders), VBP simulations showed no such outcome. On the contrary, they incentivized differentiation in a model with fixed production costs and allowed pricing diversity in a model with production cost functions depending on the business strategy.

6 Discussion

First section of the analysis identified three competitors within diagnostic imaging as being in unique organizational situations. Philips represents a fully healthcare focused and independent company, Siemens represents healthcare focused but semi-independent company and GE healthcare-focused division of a major industrial conglomerate. Relating the organizational circumstances to the Porter's generic strategy

[64] while the $P_x \Rightarrow v_P > v_S$ still holds, the differentiated firm would in this case have to engage in a price competition where the total cost C_P would exceed bidding price required to win tenders

framework, Philips as a company effectively exercising focus strategy, was expected to perform relatively good compared to its peers. Analysis of the financial measures, however defined Philips as a least profitable company, despite having the highest revenues, human resources and research expenditures. Instead, two of the competitors achieved higher profitability with comparable resources, with Siemens being the best performer. Unsurprisingly, the profitability of the companies directly correlates with their respective market shares on the diagnostic imaging market. On the other hand, it was surprising that the company with the highest research & development expenditure was significantly underperforming GE which has only half as big research and development costs.

This discrepancy prompted further study of the product portfolio in terms of its positioning (premium, middle, low) for the three companies. After classification of the devices of each firm into the three categories, two of the companies were identified as having premium focus – Siemens in the MRI modality and Philips in the CT modality – thus corresponding with the comparable R&D expenditures of the two companies. GE's product portfolio was found to be positioned in the middle in both modalities, which corresponds to the relatively low R&D expenditure (i.e. generic products).

Still the discrepancy in the performance of Philips and Siemens remained unexplained. Possible answer to the problem proved to be total size of the product portfolio of the two companies. Siemens and GE both offer much more products densely distributed in terms of vertical segments, whereas Philips' portfolio for both modalities is relatively small and concentrated (higher segment in CT and lower segment in MRI). Based on these findings a theory was developed suggesting that the competitive advantage in the market defined by price-based tenders depends on the ability of the firms to offer a range of products in all qualitative segments and thus minimizing the loss from the overprovision of quality relative to the requirements of the buyers.

Translated into the Porter's competitive positioning theory, differentiation strategy is not rewarded in the market defined by purely price-based competition, as buyers are indifferent towards the horizontal and vertical differentiation. Instead competitors have to gain advantage by maximizing the profit margins either by choosing cost-leading strategy (GE with low R&D expenditure and relatively generic products) or by strategy of minimizing the indirect losses resulting from quality/price overprovision resulting from segmentally dispersed product portfolio (i.e. indirect cost-leadership).

The hypothesis that the strategies other than cost-leadership are unsustainable in the price-only tender environment were subsequently tested with the game-theoric

simulation. Based on the two models studied it was concluded that differentiation strategy is truly disadvantageous and cost-leadership strategy is dominant. Finally, a similar simulation was performed assuming that buyer try to maximize value of the procurement with introduction of a quality criterium into the tender award mechanism. Based on the two models using this assumption, it was found out that departure from price-only procurement really has potential to allow competitive advantage through the strategy of differentiation, while at the same time improving outcomes for all stakeholders.

Regarding the contribution to the existing literature, this research has three main outcomes. Firstly, it shows usefulness of the game-theory as a tool for the strategic analyses. Secondly, it represents an early attempt to draw links between the implementation of the value-based healthcare, and the field of strategic management through the analysis of procurement practices. Thirdly it proves the value of Porter's generic strategies, often criticized for their reductionist view, for the simplified modeling of the strategic landscape. In addition, they are perfectly applicable for the initial stages of value-based healthcare.

In terms of outcomes for business practice, the analyses performed show growing importance of strategic management in the healthcare industry. Based on the models approximating value-based market, the changes to the competitive landscape resulting from the increasing importance of quality components has potential to change distribution of power not only between the competitors, but also relative to buyers, as under VBHC they exert less control over the outcomes of tenders.

Finally, despite the promising findings, it is necessary to note substantial limitations of this research. First major limitation is the lack of robust empirical data that would support the findings. Game theory after all offers only a very simplified version of the modeled situation. As I have mentioned before, healthcare is an extremely complex industry, where many factors could completely change the outcomes. With this in mind, it is necessary not to overstate reliability and validity of the findings. Therefore, the main irrefutable outcome of the study has to be limited to a following statement: It is highly probable that VBHC will gradually erode dominance of the cost-leadership strategy.

7 Conclusion

The starting hypothesis of this paper was a notion that companies in oligopolistic market competing exclusively on price can only gain competitive advantage by achieving a cost-leadership strategy. The second hypothesis was that VBHC will allow for a range of realizable strategies granting competitive advantage. Both hypotheses were accepted by means of game-theoric simulation. In conclusion the answer to the research question is:

The analyses performed herein indicate a positive effect of the value-based healthcare, so far materialized through the value-based procurement, on the diversity of feasible generic strategies available to the diagnostic imaging firms. In addition, the very nature of the value-based procurement defined in most basic terms as quality/price, very much resembles Porter and Teisberg's (2006) healthcare value defined as quality of patient outcomes/price. It is therefore possible to conclude high alignment between the goals of value-based healthcare and the value-based procurement as a main enabler.

From the perspective of strategic management, the research points to a continued validity of the Porter's competitive positioning theory and its good fit with the game-theory.

Besides the main finding described above, a new hypothesis was formulated – that the price leadership strategy in a medical device market defined by the lowest-price award criterion can also be achieved by maximization of number of products on the market defined price/quality curve.

Finally, as outlined in the discussion, this research best serves as a foundation for a further empirically more robust study, rather than a precise account or even prediction the actual developments in the real world. Still it provides a good starting point for thinking about the broader impact of value-based healthcare. Considering that the value-based healthcare implementation gradually gains momentum, field of strategic management will gain plenty new opportunities to study its transformative effects.

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9 Appendix

Appendix 1

Manufacturer	Scanner	Detector Rows	Spatial Resolution (lp/cm)	Spectral
Philips	Iqon			Yes
Siemens	Somatom Force	192	32	Yes
GE	Revolution CT	256	21.5	Yes
Siemens	Somatom Definition Flash	128	30	Yes
Philips	iCT Elite	128	24	No
Siemens	Somatom Drive	128	24	Yes
Siemens	Somatom Edge Plus	64	30	Yes
Siemens	Somatom Definition Edge	64	30	Yes
Philips	iCT SP	64	24	No
Philips	Ingenuity Elite	64	24	No
Philips	Ingenuity Core	64	24	No
GE	Revolution HD	64	21.4	Yes
GE	Revolution EVO	64	19.7	Yes
GE	Revolution Frontier	64	18.2	Yes
GE	Optima CT660	64		No
Siemens	Somatom Perspective 128/64	64	17.5	Yes
Siemens	Somatom Definition AS+	64	17.4	Yes
Siemens	Somatom Go.Top	64	15.1	Yes
Siemens	Somatom Perspective 32/16	32	17.5	Yes
Siemens	Somatom Definiton AS	32	17.4	Yes
Siemens	Somatom Go.Up	32	15.5	No
Siemens	Somatom Go.All	32	15.1	Yes
Siemens	Somatom Scope	24	17.5	No
Philips	Ingenuity Flex	16	24	No
GE	Optima CT540	24	15.4	No
GE	Optima CT520	24	15.4	No
GE	Revolutuion ACT	16	18	No
Siemens	Somatom Go.Now	16	15.5	No
Philips	MX16EVO	16	15	No

Appendix 2

Manufacturer	Scanner	Field Strength (Tesla)	Gradient (mT/m)	Slew Rate (T/m/s)
Siemens	Magnetom Terra	7	80	200
Philips	Ingenia Elition 3.0T X	3	45/78	220
Philips	Ingenia 3.0T CX	3	80	200
GE	Signa Premier	3	80	200
Siemens	Magnetom Prisma	3	80	200
Siemens	Magnetom Vida XT	3	60	200
Philips	Ingenia 3.0T	3	45	200
Siemens	Magnetom Vida XQ	3	45	200
Siemens	Magnetom Skyra	3	45	200
GE	Signa Architect	3	44	200
GE	Discovery MR750w	3	44	200
Philips	Ingenia 1.5T CX Nova	1.5	66	180
GE	Signa Pioneer	3	36	150
Siemens	Magnetom Sola XQ	1.5	45	200
Siemens	Magnetom Aera XQ	1.5	45	200
Siemens	Magnetom Avanto SQ	1.5	45	200
Siemens	Magnetom Spectra	3	33	125
GE	Signa Voyager	1.5	36	150
GE	Optima450w	1.5	34	150
Siemens	Magnetom Sola XJ	1.5	33	125
Siemens	Magnetom Aera XJ	1.5	33	125
Siemens	Magnetom Amira	1.5	33	125
Siemens	Magnetom Sempra	1.5		
Siemens	Magnetom Avanto Q	1.5	33	125
Philips	Ingenia 1.5T CX	1.5	33	120
Philips	Ingenia 1.5T S	1.5	33	120
Philips	Ingenia 1.5T	1.5	33	120
Philips	Ingenia Prodiva 1.5 CX	1.5	33	120
GE	Signa Artist	1.5	33	120
GE	Signa Explorer	1.5	33	120
GE	Signa Creator	1.5	33	120
Siemens	Magnetom Essenza	1.5	30	100
Siemens	Magnetom C!	0.35	24	55