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Theory of Constraints

A Transformation for use in the Public Hospital Sector

MASTER'S THESIS

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Abstract

A prerequisite for a safe and functioning society is to have an effective and well-functioning hospital. Hospitals are large scale complex systems that we all depend upon in situations when we are on our lives are at the most critical. The hospital sector has continually changed for the last several decades and experienced a constant shift in their day-to-day work. Today, the hospitals face increased pressure caused by increasing expectations from the users and society at large. At the same time, the cost of the workforce has raised drastically for the industrialized countries, causing an increased focus on cutting the cost of running the hospitals. The demand for cost-effectiveness is even more true for the publicly provided healthcare services that for each day that goes is put under a higher degree of scrutiny. Facing challenges such as these, have required healthcare managers to develop strategies to cope.

Ever since the technical revolution that introduced the concept of dealing with large amounts of units (better known as mass production) the industry has developed and refined their methodologies and their approaches has seemed to be immensely fruitful (J. P. Womack, Jones, & Roos, 1990, p. 26). These methods have crystallized itself into its own discipline within general management into what is now known as operations management (OM). However, as one can imagine, the process of implementing and transfer these concepts and frameworks into health care is not straightforward as there are substantial differences between these two enterprises. Not to mention that operations in the manufacturing industries mainly deal with machines and goods, and the hospital sector is mainly dealing with peoples. In the forefront in this movement of improving the operations of hospitals is the Institute of Healthcare Improvement (IHI). As will be elaborated further in the next section, IHI argues for implementing OM principles to hospital operations but does not mention the potential of the Theory of Constraints in this respect.

The project encapsulated in this dissertation is going to look at the possibility to adapt the core of one of the most promising operations management methodologies; Theory of Constraints to be applicable for the hospital setting. From the Theory of Constraints-community, there seems to be a unanimous consensus that the theory will fit very well for the operation of the hospital. However, doing so necessitates a thorough and profound work of transformation. This dissertation will take the theory apart, and by using principles found in cross-industry innovation perform a new transformation of this methodology.

By using the ACAP's process view as an overarching methodological approach, that substantiated this dissertation's project in particular, by structuring a way of carrying out the project in a systematic way. First, through an assimilation of the theory part of this dissertation where the general theoretical landscape of operations management was reviewed. Here it was also performed a literature review of the past performed TOC-implementations to pinpoint the problem in the past implementation in the hospital setting.

The problem of this dissertation was based on the identified societies' insatiate need for health care across the population to attempt to adjust the fruitful theory of TOC that has proven utility in the industry sector. The project of the dissertation has endeavored an attempt to fill the theoretical gap that has abstained the healthcare improvement community from using TOC in their improvement processes.

The resulting transformed value structure conceptually provided the allowance to implement into the values of the public hospital sector. Also, the resulting framework has the flexibility for several simultaneous goals, which is beneficial for an organization that can not operate solely on profit maximization and needs to have goals in addition to that. Another quality of the resulting framework is that it provides acceptance of leadership values such as trust.

Acknowledgment

I want to thank my supervisors, Jan Frick, and Eric C. Brun, at the University of Stavanger for the help and encouragement during this project. It has been a very educational process, and your insights and constructive feedback have been invaluable for me. I am sincerely grateful for this, and it has been a great honor working with such competent professors and researchers.

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Chapter 1: Introduction

A prerequisite for a safe and functioning society is to have an effective and well-functioning hospital. Hospitals are large scale complex systems that we all depend upon in situations when our lives are at the most critical. The hospital sector has continually changed for the last several decades and experienced a continuous shift in their day-to-day work. Today, the hospitals face increased pressure caused by heightened expectations from the users and society at large. At the same time, the cost of the workforce has grown drastically for the industrialized countries, causing an increased focus on cutting the cost of running the hospitals. The demand for cost-effectiveness is even more true for the publicly provided healthcare services, as these are for each day that goes, is put under a higher degree of scrutiny. Facing challenges such as these, have required healthcare managers to develop strategies to cope.

In 2000 the Institute of Medicine published the seminal report "To ERR is human" (Kohn, Corrigan, & Donaldson, 2000) in which purported there to be a large number of error performed by the American hospitals. From there on the recognition and emphasis kicked off the emergence of the particular focus on patient safety as one of the few flagship dimension for improvement of the hospital (Ronen, Pliskin, & Pass, 2006).

In Norway, healthcare is a public good funded by taxpayer money. It is the governments' responsibility that each aspect of patient care is as good as it can be, while still being cost effective in order to offer the best services to the public. Because of the stringent and limited timeframe rationalized to each patient, there is a worrying problem in today's operation of hospitals that the healthcare professionals do not have time to manage the soft aspect of their job (Huse Amundsen, 2013; J. Johnsen & Brynhildsen, 2018; Røhme & Kjekshus, 2001). Even though Norway is one of the wealthiest countries per capita, according to Commonwealth Fund the Norwegian healthcare system scores worst of all in overall quality compared to the other countries that we would otherwise make a comparison to (Davis, Stremikis, Squires, & Schoen, 2014). (Terning, Aallontie, Lande, & Ali, 2018)

Ever since the technical revolution introduced the concept of dealing with large amounts of units (better known as mass production) the industry has developed and refined their

methodologies and their approaches has seemed to be immensely fruitful (J. P. Womack et al., 1990, p. 26). These methods have crystallized itself into its own discipline, within general management, into what is now known as operations management (OM). However, as one can imagine, the process of implementing and transfer these concepts and frameworks into health care is not straightforward as there are substantial differences between these two enterprises. Not to mention that operations in the manufacturing industries mainly deal with machines and goods, and the hospital sector is mainly dealing with peoples. In the forefront in this movement of improving the operations of hospitals is the Institute of Healthcare Improvement (IHI). As will be elaborated further in the next section, IHI argues for implementing OM principles to hospital operations but does not mention the potential of Theory of Constraints in this respect, which is the chosen theory for this dissertation.

The project encapsulated in this dissertation is going to look at the possibility to adapt the core of one of the most promising operations management methodologies; Theory of Constraints to be applicable for the hospital setting. From the Theory of Constraints-community, there seems to be a unanimous consensus that the theory will fit very well for the operation of the hospital. However, doing so necessitates a thorough and profound work of transformation. This dissertation will take the theory apart, and by using principles found in cross-industry innovation attempt a new transformation of this methodology.

Structure of this Dissertation

The structure of this dissertation deviates from the typical empirical study. It relates to that typical structure in the following way; CHAPTER 1 and CHAPTER 2 make up the introduction and background. SUBCHAPTER 2.3 will state the problem and goal. CHAPTER 3 explains the methodological aspect of the dissertation that is used to solve the problem and accomplish that goal. CHAPTER 4 provides the necessary relevant theory. CHAPTER 5, along with CHAPTER 6, constitutes the analysis. First processing the theory together with the suggested methodological framework and refines the theory for its expanded roam of usage. Secondly provides an example of an implementation for the values of a publicly funded hospital, Stavanger University Hospital. These two chapters contain what is to be regarded as the novel contribution of this dissertation. The discussion of the different elements of the analysis is presented in CHAPTER 7, and finally, CHAPTER 8 concludes this dissertation.

Chapter 2: Background

This chapter provides background for the landscape and circumstances this dissertation mainly operates within. It will set the stage for this thesis an attempt to give sufficient rationale for why the work behind this thesis is worthwhile. Also, this chapter aims to give a concise introduction to the central topics with some historical perspective and build a fundament to the different topics discussed later in this thesis. First, the chapter points out the identified needs of the healthcare community (SUBCHAPTER 2.1). Give a brief explanation of the theoretical gap (SECTION 2.2) and after that, provide the problem statement for this dissertation. At the end of this chapter, a brief overview of the structure of the rest of the thesis will be provided (SUBSECTION 2.3.1).

2.1 The Healthcare Communities' Needs

This subchapter aims to shed light on and lay out what is the identified need from the health care improvement community itself at general and what broad-view challenges they face seen from a broad perspective on the societal need.

2.1.1 Healthcare Improvement Community

In 2017, Rutherford et al. representing the Institute for Healthcare Improvement (IHI) released the whitepaper "*Achieving Hospital-wide Patient Flow*" as a conclusion of 20-years research (Rutherford, Provost, Kotagal, Luther, & Anderson, 2017). The directive of the whitepaper was to suggest implementing different approaches and measures to raise patient-flow at the system-level. IHI suggests in their whitepaper several different actions and measures that at least seems to have a significant connection to the methodologies found in the sphere of operation management (OM). Especially in the relation of bringing up FIGURE 2.1, the whitepaper presented five tenets of how to contribute to better the patient flow at a system level:

1) *"If each part of a system, considered separately, is made to operate as efficiently as possible, the performance of the system will be sub-optimized" (Rutherford et al., 2017, p. 8)*

2) *"Every system has a current constraint or bottleneck." (Rutherford et al., 2017, p. 8)*

3) *"Understanding variation is key to achieving optimum flow. (Rutherford et al., 2017, p. 8)*

4) *"Every system is perfectly designed to get the results it gets." (Rutherford et al., 2017, p. 8)*

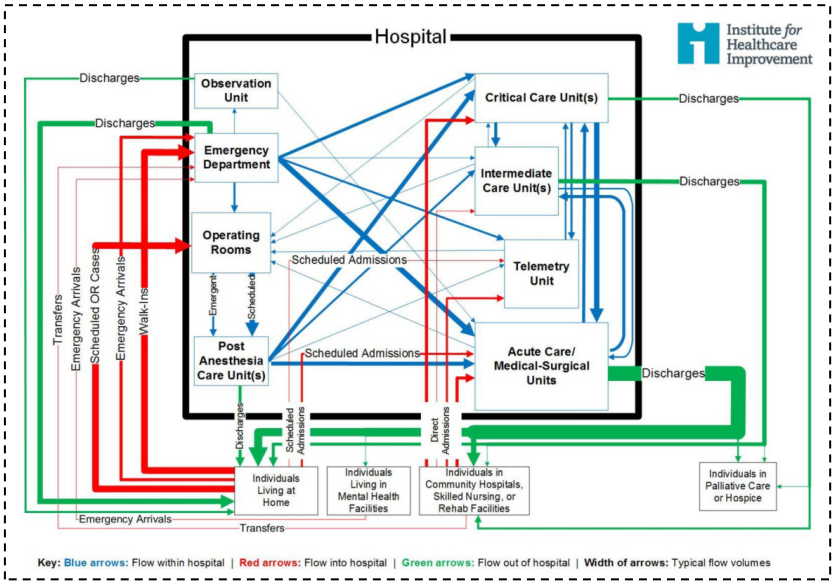


Figure 2.1 – System map showing the patient flow across different wards and units of the hospital. Presented by the introduced IHI whitepaper. A thicker arrow corresponds to a higher flow of patients in the system[1] (Rutherford et al., 2017).

Each of these points that IHI brought up in the whitepaper, is found to be recurring concepts and ideas of the Theory of Constraints, especially in the operations management. Below is listed some concrete examples of the emergence of the points in the literature;

[1] Please refer to APPENDIX A.3 for bigger version of this figure.

1) First and foremostly this is used as an essential notion in original literature of TOC the book "The Goal – A process of ongoing improvement" at pp. 68, 144, 217 (Goldratt, 1984), the notion is also recurring in the secondary literature, e.g. the book "Pride and Joy" pp. 49, 136 (Knight, 2015). This point is also a part of the principles presented in SECTION 4.3.2.

2) This is as close as the fundamental mantra of TOC as one could get, this will be presented and more elaborated in SUBCHAPTER 4.3.

3) This point has its own conceptual tool for being coped with, namely the drum-buffer-rope method that deals whit management of variability in production, which was initially presented as a "Herbie" in "The Goal" (Goldratt, 1984, Chapter 13).

4) This is tightly connected to the notion of system-view as it is presented throughout the original literature (Goldratt, 1984).

Despite the above, a striking feature of the IHI whitepaper is that it makes no explicit reference to what solutions TOC may provide to alleviate those points, as it refers mainly to Lean Management (Rutherford et al., 2017). Also, the whitepaper present that the hospital management needs to be governed by a few simple rules to govern the hospital holistically. Looking at what these points implicate, one gets the peculiar observation that those attributes match very well with what is the fundamental hallmarks of TOC (Nave, 2002).

However, –as going to be investigated later in the dissertation– past implementations of TOC in hospital settings have been tried out and have shown that it is hard to implement consistently (Aguilar-Escobar, Garrido-Vega, & Gonzalez-Zamora, 2016). As Sadat et al. put it; "*there is a lack of literature addressing the modifications required to adopt TOC and define the goal and performance measures*" (Sadat, Carter, & Golden, 2013) which is the fundamental prerequisite in order to implement TOC properly. This transformation will be addressed in a more detailed manner in SUBCHAPTER 4.1 and is going to be subject matter in CHAPTER 5.

2.1.2 General Challenges of Health Care

Hospital management has some increasing general problems and limitation that characterizes the operations of the hospital and what is faced, as time is progressing. The following subsections will present some of the leading causes, resulting in underlying operational management difficulties that have bedeviled the operations of the hospitals. The problems are two large societal problems that, in the big picture, contributes to the need for further health care improvement. More technical problems will be introduced in theory, SUBCHAPTER 4.2.

Problem of Cost

Just like the huge advances in the economy and technology has progressed, there has been a significant rise in cost and major evolvement of the hospital in general. Hospitals are more expensive than ever before, just in terms of technology (van Harten, Goedbloed, Boekhout, & Heintzbergen, 2018). Secondly –this is especially true for Norway– is the increasingly higher cost of labor has been an increasingly more relevant aspect as the country has become more and prosperous.

The Problem of Higher Life Expectancies

Now with the rising population and the uprising of elderly people from the baby-boomer period, we will face a vastly increasing demand for hospital services. Even though we are increasingly healthier, we are stretching our expected years of life and thus the expected years of health care provided by the state. When one in the past would have a higher chance of dying in their first case of cancer, one will now more often come back to resolve the next severe illnesses that incurred. So, in some way, the technology/treatment is generating more patients and thus generating heavier workload for the healthcare providers. Also, the number of treatments is steadily increasing as the medical science advance.

2.1.3 About the Norwegian Healthcare Community

As of 2017, the Norwegian healthcare spending amounted to 342 billion NOK which corresponded to approximately 65 000 NOK per capita and Norway was one of the countries with the highest spending on health care per capita in 2016 among the other OECD-countries (SSB.no, 2018). Much of this is caused by the increasingly detrimental fact of wealthy economies, in which Norway is in a particular situation as it's ranked as the second highest in

the world (FocusEconomics, 2018), This leads as the time pass by, to increasingly more significant portion of retirees and the working force will proportionally get smaller (Leseure, 2010). The wave of baby boomers combined with the setback of a lower population in the workforce caused by aspects such as higher living standards will put the nation to an exceptional and unprecedented test that will require drastic improvements in thinking.

Stavanger University Hospital

This dissertation will aim a great portion of its contribution towards the Stavanger University Hospital. The University Hospital in Stavanger (SUH) is a *large*[2] publicly funded hospital in the county of Rogaland in the south-west of Norway. It has over 7800 employees working in 33 different wards which are aimed to serve the healthcare need to a total population of 369 000 citizens (SUH, 2019) of these the hospital triages about 30.000 patients throughout the year. The hospital as a whole has a yearly budget of total 6,7 billion NOK[3] (Proff.no, 2018).

2.2 Theoretical Gap

As mentioned, Sadat et al. pointed out (SECTION 2.1.1) a lack of literature addressing what is needed for a full application of TOC in the health care sector (Sadat et al., 2013). Also, Naor et al. (2013) did an in-depth theoretical study of the theoretical elements behind the theory of constraint. Although TOC satisfied the criteria of being "a good theory" it was identified and acknowledged that the theory through future studies should be raised to a more abstract level for its extended utility in fields beyond the traditional manufacturing sector (Naor et al., 2013).

[2] *Large* by technical definition 500 beds or more (Gallagher Healthcare, 2018; SUH, 2018)

[3] Which approximately amounts to 775 million USD according to the currency translator at the noted time period (fxtop.com, 2019).

2.3 Problem Statement and Goal of this Dissertation

This subchapter will present and articulate the underlying problem and the goal of this dissertation. The subchapter in some places mentions element that is better explained later in the dissertation. First comes the problem statement (SECTION 2.3.1), which together with the introduction (CHAPTER 1), sets the motivation of the work. Following is the goal statement (SECTION 2.3.2) that will present what the work of this dissertation aims to achieve.

2.3.1 Problem statement

Humans are tied to the inescapable human condition constituted by constant health deteriorating and proneness to acute incidences. This condition accumulates and causes at societies' level an insatiate need for health care across the population. A prerequisite for having a safe and functioning society is to have a healthcare supply under continuous improvement to counter the perpetual increasing need for more health care (SECTION 2.1.2) forward. In this regard, the hospitals' functions as providers of health care for the society and has a goal to manage, allocate and convert its scarce resources in such a way that underpin the higher goal of providing the society with the increasing needed health care.

However, orienting the operational aspects of an extensive complex system such as the hospitals is an intractable enterprise to persecute. According to the whitepaper of IHI, IHI has uncovered and highlighted weaknesses that there exists a gap in the operational aspect of the hospitals today (SECTION 2.1.1). This gap in hospital operations is very costly as it is resulting in an excessive focus and furthering of the silos rather than focus on the interconnection between the functions of the hospital and thereby hindering the flow of patients throughout the hospital. Improvements still often revolve around optimizing certain functions and not keeping the whole system-view in mind. Doing so further amplifies the silo-mentality that in practice, deteriorates the patient flow (see silo-mentality explained in SECTION 4.1.2).

Looking at the manufacturing practices that have revolved around the flow of product, inventory, and other assets might yield helpful insight and could yield prosperous initiatives that alleviate the problems that IHI calls for actions to overcome. The key features of focus proposed for the furthering development of hospital management from IHI coincide much with the streaking features of Theory of Constraints, which is the chosen operational management

theory for this dissertation. A TOC adjusted to fit the characteristics of publicly funded hospitals may, therefore, be very valuable to help healthcare institutions towards achieving the improvements called for in the IHI whitepaper (Rutherford et al., 2017).

2.3.2 The Overall Goal of this Dissertation

Based on the identified societal need and the theoretical gap, this dissertation's goal is to accommodate the societal need by filling the mentioned theoretical gap. This theoretical gap will be aimed to be filled, as suggested, by providing an abstraction of the Theory of Constraints that can result in its extended use into the public hospital sector.

2.3.2.1 *Strategy for Achieving this Goal*

The presented goal is attempted to be accommodated through this present dissertation. The next chapter is going to explain the method that is the overarching structure to facilitate the achievement of the goal that is sat for this dissertation. The following figure presents the methodologies' manifestation in this dissertation's structure. The processes of acquisition, assimilation, and transformation are explained more closely in SUBSECTION 3.1.1.1-4.

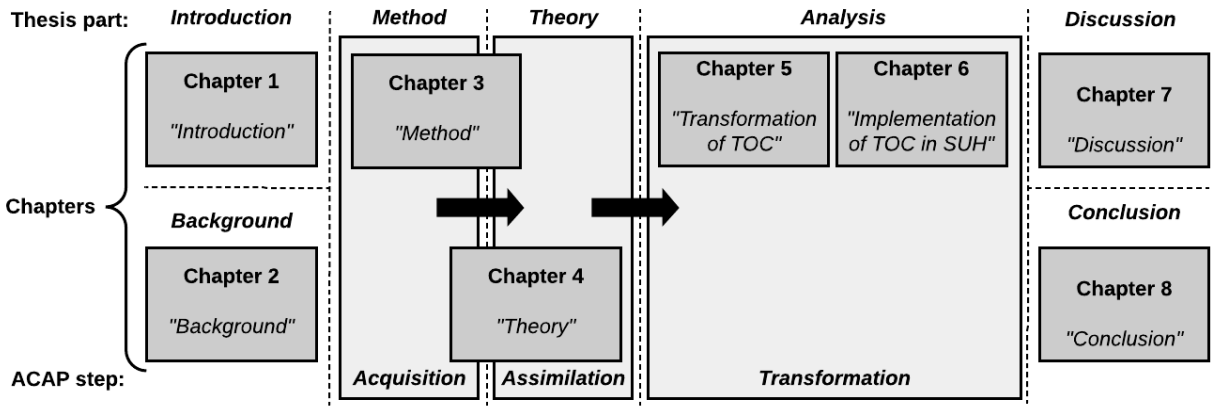


Figure 2.2 – Summarizing flow-chart of how the methodological framework relates to the general structure of *a thesis* and the chapters of *this dissertation*, which is aimed to accommodate the overall goal of this dissertation.

Chapter 3: Method

This chapter will lay out and explain the overarching theoretical procedure of how the dissertation came about and what type of methodological framework used for the dissertation. Because of this, the structure of the thesis deviates from the typical structure of a purely empirical study.

This dissertation's content is primarily characterized by its conceptual exploratory and cross-disciplinary nature. Where its resulting content, firstly is a generalized framework of operations management theory (CHAPTER 5). Also, secondly, is the integration of two distinct spheres of thought; operations management theory with its inceptive adherence in the industry-sector and clinical leadership from the publicly funded hospital sector (CHAPTER 6).

The structure and the research design of this dissertation bear the mark of a tight connection between the overall structure and its method. This connection is caused by the chosen cross-disciplinary method that is going to be presented in the first subchapter (SUBCHAPTER 3.1). The second part of this chapter presents a secondary methodology that was used to generate the mentioned generalized framework, the conceptual tool of abstraction ladder (SUBCHAPTER 3.2).

3.1 The Overall Method

The structure of this dissertation follows an overall methodology found in the literature of cross-industry innovation. Notably, the structure of the dissertation landed on taking the form similar to the Absorptive Capacity (ACAP) process (Zahra & George, 2002), through which organizations gain competitive advantage through cross-organizational knowledge transfer, i.e., making use of knowledge external to their organization.

The challenge addressed in this dissertation is that we are seeking to see how hospitals, as organizations in the public healthcare sector, can gain an advantage (as opposed to competitive

advantage that Zahra et al. (2002) focuses on) by importing and making use for external knowledge (in this case; the Theory of Constraints) from organizations in another sector (i.e., manufacturing industry). Zahra et al. (2002) present ACAP in the conceptualization a four-step process with four general distinct qualitative capabilities –or routines– within an organization: *acquisition, assimilation, transformation,* and *exploitation* of external knowledge.

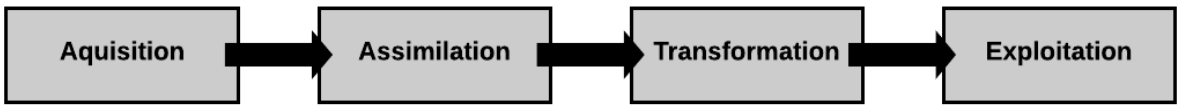


Figure 3.1 – The dimensions of ACAP put forward in the cross-industry innovation literature Zahra et al.'s (2002) re-conceptualized as a process describing the overall method of this dissertation. The two intermediate steps are what manifests it selves explicitly in this dissertation.

In the context of Zahra et al.'s work, the model describes the individual *organization* is to acquire external knowledge. However, in the context of this dissertation, it is not a matter of an *organization*, but rather *this dissertation* that is performing the routines on behalf of the *publicly funded hospital sector*. In the following section, when referring to "unit of interest," this is pointed out to illustrate the juxtaposition of the *present dissertation* and an *organization* that is acquiring external knowledge. The following subsections of this subchapter list a brief description of the four steps of the ACAP-process, situated in their original position. Together with an explanation and how the steps are underpinning this dissertation's project of theory transformation.

3.1.1 The Four Dimensions of ACAP v. this Dissertation

3.1.1.1 ***Acquisition*** denotes an organization's ability to identify and acquire (or more fundamentally; "the *attitude* towards approaching") outside and unintegrated knowledge that is crucial for the operation (Zahra & George, 2002). In the case of this project, it is not a matter of "*organizations ability*" but a sectors ability, more specifically, the healthcare sector. In short, acquisition can be summarized to be what the sector does to keep their eyes open for the external world's knowledge. Also, this dissertation contributes in itself by undertaking an acquisition process (on behalf of the public hospital sector), in where it has identified valuable knowledge about

TOC and assessed its relevance for the public hospital sector. This part of the overall process manifests itself in this dissertation in two main ways. The acquisition surfaces itself as the apriori initiative and proclivity to write about the topic at hand (i.e., healthcare's integration of TOC) in the first place. Secondly, a more concrete manifestation of this routine is the scanning of the literature which is documented in the following;

Review of literature implementing chosen theory in Hospital

A systematic literature review was performed on scientific articles in journals and report databases provided by the University Library in Stavanger;

1) ***Search in Databases;*** The resulting findings of established theory, theoretical substance and status quo will be presented in the theory chapter of this report. The different databases were equipped with different search engines with different syntax and level of sophistication of logical operators. The search was performed first on the Web-of-Science and secondly the Scopus and thirdly the PubMed database. There was an overlap in results between the searches in the different databases. Because of this, only the articles that were not already found was kept (hence the "n+7" and, so on in the second step). A minority of the articles showed to be inaccessible and consequently was not a part of this study.

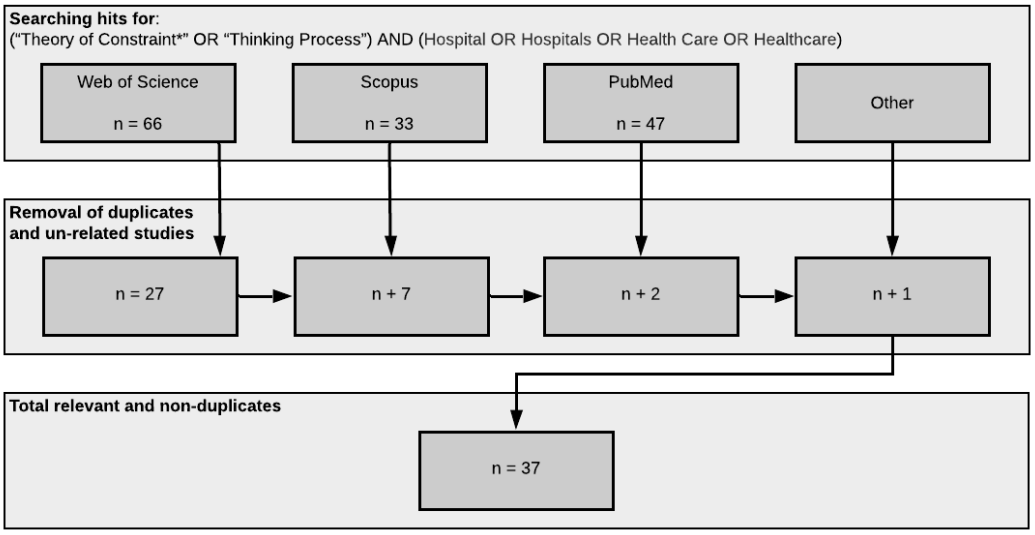


Figure 3.2 – Flowchart of the literature acquisition for scientific articles made available through the research library of the University of Stavanger.

2) ***Categorization***; As it was found paramount to distinguish between a holistic and atomistic approach (see SECTION 4.4.1 for criteria) of implementation and the scope of the chosen theory's application of the chosen theory. The n=37 articles had to be categorized in order to distinguish clearly between the contents. This categorization is performed APPENDIX A.2, and the result of the categorization is presented in SECTION 4.4.2.

3.1.1.2 ***Assimilation*** is what activities the unit of interest (i.e., firm, organization, or this dissertation) does to analyze, process, understand, and interpret the external world's knowledge (Zahra & George, 2002). In short, this is understanding how the knowledge is applied and how it is functioning under the present applications. In this dissertation, this is firstly done by studying the content found in the literature review topic. Further, the *assimilation* part also encompasses the theory chapters, where the theory is presented in the traditional context in order to set the stage for the next step. Concerning the thesis' structure, the *assimilation* is here encompassed in CHAPTER 4.

3.1.1.3 ***Transformation*** is the unit of interest's ability to refine and develop the identified external world's knowledge to a state where it is possible to implement the external world's knowledge into their operation (Zahra & George, 2002). The transformation-step is the step that genuinely generates new opportunities and enables for improvements in novel and entrepreneurial ways (Zahra & George, 2002). The transformation gets decomposed into conversion and internalization (Zahra & George, 2002), a bifurcation that also fits nicely to the structure of this dissertation. First, the conversion-component of transformation is contained in CHAPTER 5. TOC." The particular content of the thesis' conversion will be furthermore explained in the next subchapter as this contains subparts that have been pivotal for the theoretical work of this project. Second, the internalization-part will consequently consist of recognizing the implication the converted knowledge will have on today's operation. Shortly and more concisely, it is theorizing how it can be carried out in practice. This second internalization-component of transformation is contained mainly in CHAPTER 6.

3.1.1.4 ***Exploitation*** is the group of activities where the unit of interest incorporate the newly gained knowledge generated by the transformation step into their day-to-day operations (Zahra & George, 2002). As this entails the purely practical activities of performing the implementation of the transformed knowledge to the operation of the unit of interest, this dimension is beyond

the scope of this dissertation, and this is how far this framework has utility in a purely theoretical deployment of the framework (such as this dissertation). This step can, in short, be summarized as the ultimate ambition of this dissertation; that its content will be picked up by an organization or sector to carry the transformed theoretical approach articulated in the dissertation as an instrument for improving the operations.

3.1.2 The Overall Methods v. the Thesis' Structure

As mentioned in the introduction of this chapter, the overall method is something that is contained in a large portion of this overall dissertation; it starts with the literature review and ends with the start of the discussion. The figure presented in SUBSECTION 2.2.1.1 shows how those mentioned steps; *acquisition*, *assimilation,* and *transformation* stands in relation to the chapter of this dissertation in a flow-chart representation.

3.2 Transformation through Abstraction

In this dissertation, abstraction has been used to conduct and underpin what is the main contribution of the work. The theories that have been consulted in this work has mainly been from the fields if neuroscience and artificial intelligence. The latter field had a concise description of the "process" of abstraction;

> *"Roughly speaking one can think of abstraction as the process which allows people to consider what is relevant and to forget a lot of irrelevant details which would get in the way of what they are trying to do." (Giunchiglia & Walsh, 1992)*

The word "abstraction" has various meanings and is often conflated with generalization. The act of abstraction is the process to look beyond the specifics in order to find a deeper and more generalizable pattern that can be used to talk intelligibly about (ref). Abstraction is usually performed with the assumption that there is something valuable in the substructure of a certain phenomenon. The particular methodological way abstraction that is used in this dissertation is the one found in general semantics (GS), which in short can be explained as "[GS] is a discipline drawing upon the best scientific methods for a deep restructuring of a human being to make optimal use of their potentialities"—A. W. Read (Wanderer, 2007). SECTION 3.2.1 introduces

the central tool (the abstraction ladder) used in GS and point out where and how it is used in this project.

The abstraction in this dissertation is performed in the transformation-step (SUBSECTION 3.1.1.3) of the ACAP-process mentioned above. The abstraction as a methodological instrument appears at its use in CHAPTER 5, where the transformation is performed as a means for transforming the central parts of the Theory of Constraints (TOC). Use of abstractions is also found to have merits in the literature of cross-industry innovation. Gassmann et al. show how firms use analogical thinking –that contains abstraction– to support development in cross-industry innovation (Gassmann & Zeschky, 2008). This conceptualization in that literature is analogous to what is done here, the main difference being that instead of being concerned of innovation across *industries* this abstraction is performed in order to transfer knowledge from one theoretical framework to be resituated into another. Another distinction is that Gassmann and Zeschky (2008) is mainly elaborating on a specific problem. In this dissertation, there is not the knowledge for solving any specific problem that gets transformed, but the mechanics of what is in the core of a theory that is the subject of transformation. This core gets transformed from fitting one type of organizations (profit-maximizing) to another set of organizations (publicly funded hospitals).

3.2.1 The Abstraction Ladder

The process of abstraction and concretizing has been conceptualized by ascending the abstraction ladder. The abstraction ladder originates from S.I. Hayakawa's interpretation and refinement (Hayakawa, 1972, p. 126) of A. Korzybski's "Structural Differential"-framework (Korzybski, 1995, pp. 393-). Figures of this framework with original explanatory text are enclosed in the figure following this paragraph. The abstraction ladder ranges from the process level at the bottom to the higher-order abstract verbalizations at the top. The different intermediate steps on the ladder delineated as different "orders of abstractions." The lowermost process level is what is interfacing the boundless (or the infinite; meaning the unlimited physical object (illustrated by the corrugated line at the bottom) that gets delimited through the context of human interpretation, which is illustrated by the concave "finite" border interfacing the overlying levels of abstraction).

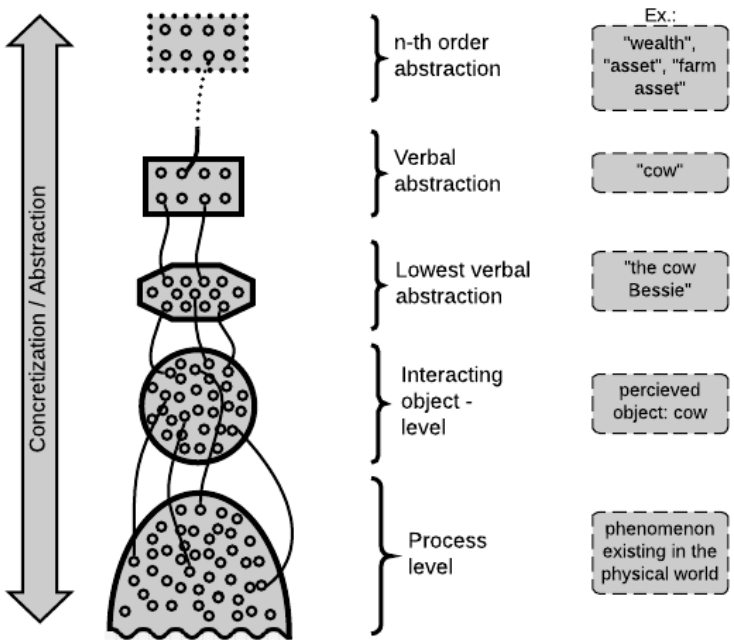


Figure 3.3 – Ill. of the abstraction ladder[4]; shows how the different levels of abstractions differentiate between with the concrete example of a cow.

3.2.1.1 *The Different Steps of the Abstraction Ladder*

Different levels of abstraction are represented by the different steps on the abstraction ladder. The higher up, the more abstract the conceptualization is. As we see from the transition between the lowest and second-lowest steps of the abstraction has a physical nature to it. However, among the uppermost levels on the abstraction ladder, the abstractions are purely verbal. In Korzybskis' version of the abstraction ladder (which he called "the structural differential") the second lowest steps (interacting object - level) is interestingly indicated by "Fido" as a delineation of where humans apart from animals in the sophistication of abstraction. This dissertation is only going to deal with levels beyond this second one, i.e., levels of verbal abstractions.

[4] Redrawn and modified from the work of H. I. Hayakawas' interpretation (Hayakawa, 1972) of Albert Korzybskis' Science and Sanity (Korzybski, 1995)

Chapter 4: Theory

The present theory chapter is the first step of the ACAP-process (presented in SUBCHAPTER 3.1) that manifests itself in its entirety in this dissertation. The assimilation process of this dissertation is conducted by, first studying and presenting the general theoretical universe of the field. Then look at what potential implications it has on the public hospital sector, presenting the main and essential ideas in the theory that is subject for transformation.

This chapter was chosen to be divided into four distinct subchapters that all serve each a different purpose in the assimilation-step of the method (SUBCHAPTER 3.1). First, it introduces operations management (OM) at the general level, aside from the hospital setting (SUBCHAPTER 4.1). Then the next subchapter presents the OM-specific problems that exist in the hospital setting (SUBCHAPTER 4.2). The third and fourth subchapter presents the chosen theory to transform (SUBCHAPTER 4.3) and review the literature that has applied the theory in the hospital sector in the past (SUBCHAPTER 4.4).

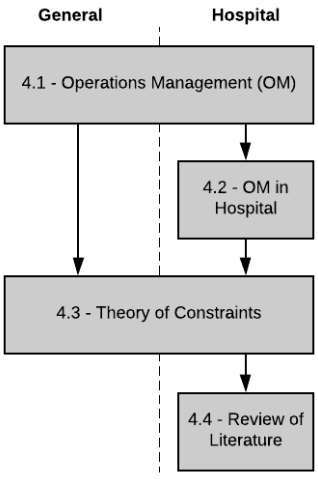


Figure 4.1 – Linkages between the different subchapters of this theory chapter. The right-adjusted subchapters concern hospital and the wide subchapters are general.

4.1 Operations Management

This subchapter will provide both a frame of reference for what operations management constitutes and display its relevancy in today's management of businesses.

4.1.1 What is Operations Management?

OM is a discipline that appeared in the wake of the second industrial revolution. It has been nested in the family of business studies despite its many deviating qualities from its counterparts, e.g., accountancy, marketing, finance. These deviations stem from the fact that OM has roots from other places; such as management and industrial engineering. Although it practical roots, it has in ways maintained and continued its presence in the academic sphere because of its undisputable utility from its implementations in the industry (Leseure, 2010).

The word "operation," in "operations management" is not to be conflated with the procedure of performing a surgical intervention on a living body. But is used to encapsulate all the activities that an organization performs to output whatever they produce. What is being produced could be either a product, service or most commonly a combination of those (Heizer, Render, & Munson, 2017, p. 4; Slack, Chambers, & Johnston, 2009, p. 5).

Operations management itself has been viewed as the amalgam of many crystalized theoretical frameworks (e.g., Lean, TOC), tools and methods from those frameworks (e.g., JIT, Kanban), tools, methods, and concepts outside from any theoretical frameworks (e.g., queue theory, supply chain management, etc.). The main concerns of operations management revolve what is happening inside the organization and how to carry out improvement of the processes that are producing whatever is made in the facility of production.

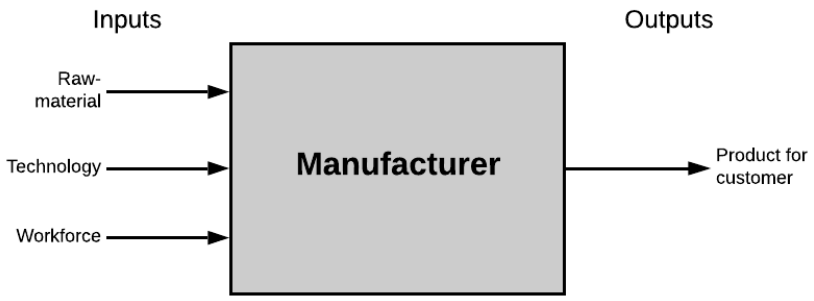


Figure 4.2 – Simplified illustration of a traditional pure manufacturer in the system-view exemplified with different inputs and outputs. OM concerns everything inside the organization that is transforming input to output.

4.1.2 Why Operations Management?

Consumers demand is known to increase both in size and complexity grounded in the insatiable want for better lives. To accommodate this ever increasing entropy of demanded products and services; that manifests itself as the demand for more complex products and services along with demand for a more specialized selection of products. The operation of producing those gets disproportionately more complex and that in turn requires more intricate managing of those operations.

Human intuition has and will continue to take us pretty far in coordinating operations. However, as the complexity of operations always increase the managing of the operations foster a need for increased sophistication (e.g., systematization, critical thinking). And this is what operations management helps to cope with.

4.1.3 Different Philosophies of Operations Management

OM contains several different theoretical philosophies that have appeared from different places in time and geographical location. This section will present the most popular OM-methodologies that was appropriate to consider as candidates for this dissertations project.

Most of the literature mentions Lean Management and the different variants of quality management (QM) methodologies as relevant operations management methodologies to utilize in healthcare improvement, and only a few include TOC. Other than that, there are few methods mentioned in the literature. However, these are mostly variations or precursors of QM

methodologies (e.g., Total Quality Management, ISO9000). Moreover, because Six Sigma is regarded as the pinnacle of those by being the most popularized one, it is not included further methodologies in the discussion. The next subsections will present and compare the leading system-wide OM-methodologies Lean Management, Six Sigma, and Theory of Constraints:

Lean Management is the most widespread and very popularized OM-methodology sweeping the world at the present time (Heizer et al., 2017, p. 57). It emerged as the western interpretation of the Eiji Toyoda and Taiichi Ohno's way of improving the operations of the world-known car manufacturer Toyota. Lean Management focuses on increasing throughput by reducing *waste*; everything that is not of value for the customer should be eliminated from the operations (i.e., make what the customer exactly wants). The different wastes that are occurring are systematized into seven categories; overproduction, queues, transportation, inventory, motion, over processing and defective product (Heizer et al., 2017, p. 676). Out from this, there are the 5's to alleviate those; sort/segregate, simplify/straighten, shine/sweep, standardize, sustain/self-discipline (Heizer et al., 2017, p. 677).

Six Sigma emerged from and was developed by the senior engineer and scientist Bill Smith in the company Motorola in 1986 (Barney, 2002, p. 13). Six Sigma is a science-based OM-methodology. The primary tenet of this methodology is to aim for the production to achieve a failure rate (or accuracy) equal to the interval encompassed by 6σ (i.e., six standard-deviations, and hence its name; Six Sigma) centered about the mean (Heizer et al., 2017, p. 259). E.g., in the case of an airport luggage system no more than 3,4 misplaced luggage out of 1 million are acceptable (i.e., 3,4 parts per million) (Heizer et al., 2017, p. 259). Following the methodology this performance should be accomplished by implementing the DMAIC-process (define, measure, analyze, improve, control) guided by seven instrumental tools; check sheets, scatter diagrams, cause-and-effect diagrams, Pareto charts, flowcharts, histograms and statistical process control (Heizer et al., 2017, p. 259).

Theory of Constraints was invented in 1986 by the Israeli physicist Dr. Eliyahu Goldratt. The philosophy of Theory of Constraints (TOC) has its main focus on the management of capacity constraints (Slack et al., 2009, p. 456). A constraint gets defined as "anything that limits a system from achieving higher performance versus its goal," and each organization has a one or at least very few bottlenecks (Goldratt, 1984), and the major tenet behind this methodology is to limit that constraint's impact. These limiting constraints are managed by focusing, which is

formalized through the *five focusing steps*; *Identification*, *Exploitation*, *Subordination,* and *Elevation* of constraints (Pretorius, 2014, p. 497), the *thinking process* or by *drum-buffer-rope* (also known as *buffer management*).

> The more extended version of why this chosen methodology is given in SUBCHAPTER 2.1 and further explained in SUBCHAPTER 4.3.

Comparing and Contrasting the Philosophies of OM

In a superficial examination, it might seem that the methodologies, most notably Lean Management and Theory of Constraints, have more in common than they are different. However, in closer examination, there are profound differences in features, principles, focus, and in what is emphasized that possibly results in significant differences when implementation is performed. A theoretical investigation of the differences between the three main methodologies has been performed, and a summary of the comparison is presented in TABLE 4.1. (Muriki, 2012; Nave, 2002)

Since the methods in their essence all focus on throughput, one could say that the methods are more similar than they are different (Pacheco, 2015, p. 519). However, there are subtle differences in their foundational aspects, that play out and results in a more significant difference in aggregate over time. As we see, all of them focus on the increasement of throughput. Just that Lean does this by removing waste, Six Sigma by reducing variability and theory of constraints by *focusing* on constraints. Table 4.1 and contrast the focal points of these three mentioned methodologies:

Table 4.1 –Summary from a comparison of the OM-methodologies Lean Management, Six Sigma, and Theory of Constraints. (Muriki, 2012; Nave, 2002)

OM-method.:	Lean Management	Six Sigma	Theory of Constraints
Theory	Remove waste	Reduce variation	Manage constraints
Application guidelines	1. Identify value 2. Define value stream 3. Determine Flow 4. Define Pull 5. Improve process	1. Define 2. Measure 3. Analyse 4. Improve 5. Control	1. Identify the constraint 2. Exploit the constraint 3. Subordinate processes 4. Elevate constraint 5. Repeat cycle
Primary Effect	Reduced flow time	Uniform Process output	Fast Throughput
Tool	Visualization tools	Statistical tools	Thinking process
Focus	Focused on system	Focused on Problem	Focused on system Constraints

Following diagram shows the development of big of the portion of the general literature that has been written within these three OM-methodologies over the years:

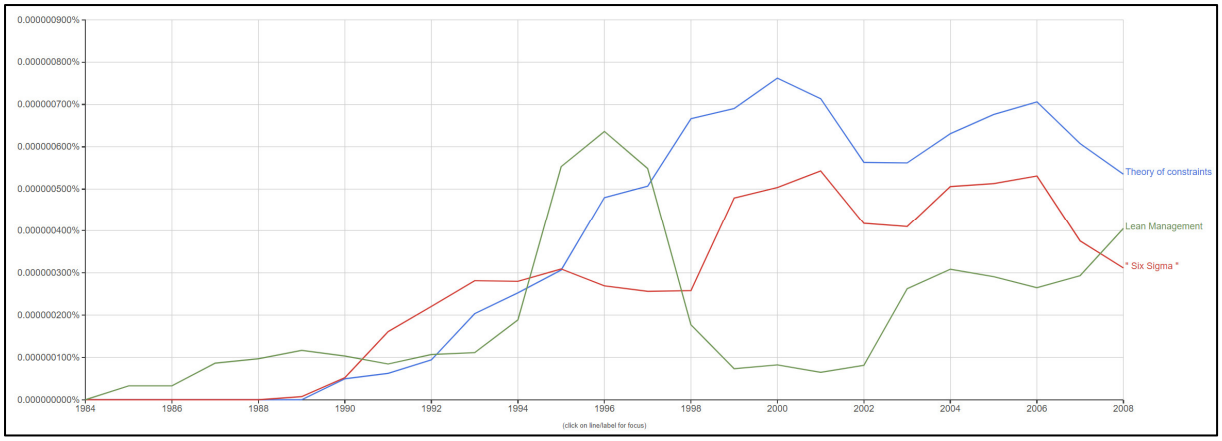


Figure 4.3 – Diagram from Google Ngram showing the relative portion of books written on TOC (blue), Lean Management (green), and Six Sigma (red) (Google Ngram, 2019).

4.1.3.1 *Synergic Variants of the OM-methodologies*

This subsection will present and problematize hybrids of operations management that has emerged in the aftermath of their prevalence. The first category is the synergic combinations of the three mentioned primary methodologies, and the second category is re-invention of TPS for specific companies, also called XPS:

Synergic Hybrids of the Three Main OM methodologies

In the aftermath of the emergence of these three main methodologies, it has at least in the literature been proposed to combine the different methodologies. Intuitively this makes sense as the different methodologies could bring its best qualities to the table. However, doing so might dilute the change of operations. Varieties of combinations of these three theories are proposed in the literature;

- "Lean Sigma," "Lean Six Sigma" or (LSS, LM&SS)
- "Lean Theory of Constraints" (LTOC)
- "Theory of Constraints Lean, Six Sigma (TLS) (Pinnacle Strategies, n.d.)

Organization Specific Production System (XPS)

The second category of hybrid versions of operations management methodologies is the result of the acknowledgment of the great results produced by the Toyota Production System (TPS). TPS contained a bundle of OM concepts such as waste reduction, JIT, Kaizen, autonomization, etc. Examples of XPS in the real world are systems such as; Volvo-, Audi-, Boeing-, Bosch-, Caterpillar-, Rolls Royce-, Productions System, and more (Netland, 2013). XPS deals with different concepts (e.g., tools, methods, principles) abstracted from its holistic framework and has a more tool-box utilization of the underlying methodologies. However, as it seems as a best-of-all-worlds situation, without a rigid holistic fundament that guides the usage of the initiatives in an overarching manner it might lead to inconsistent implementation (Pacheco, 2015, p. 519). This problem will be reverted to and discussed further in the discussion about inconsistency in the past implementation of the TOC (SUBCHAPTER 4.4).

Discussion of Hybrid Methodologies

A synergic model of the kinds discussed here may not be in the exclusion of the work done in this present dissertation; it could be regarded as a possible extension of the developed theory. Because of this, the further work of this dissertation will not bring forward an investigation of

these hybrids as it would expand the scope of the work to an unmanageable size. Even though it very well could be a part of the final solution of getting to an optimal hospital improvement methodology. An investigation of such an initiative would be heavily encouraged and could be one of many different extensions of this work (this is reverted to in the discussion CHAPTER 7).

4.1.4 Load Oriented Manufacturing Control

Alongside and parallel to the emergence of TOC, there appeared independently a similar theory called Load Oriented Manufacturing Control (LOMC). This theory was built in the academic sphere in Universität Hannover (Bechte, 1988). In contrast from TOC that appeared from a physicist that used his Socratic reasoning. LOMC, however, got constructed and refined by a rigid manufacturing management research group in three universities in Germany (Breithaupt, Land, & Nyhuis, 2002). LOMC went further than TOC when it came to articulating management of statistical deviation in production, as the TOC's way of dealing with statistical fluctuations is conceptually through drum-buffer-rope (Thurer, Stevenson, & Renna, 2019). The figure below shows an excerpt illustration from the literature that presents strong conceptualizations of the theory that also bring resemblance of the TOC-problematization, although with additional insight. The literature written about this theory might be auxiliary and show to be fruitful when combined when dealing. Later, this dissertation is going to develop

further and expand on the useful analogy that is found throughout the literature of LOMC (SUBCHAPTER 5.4).

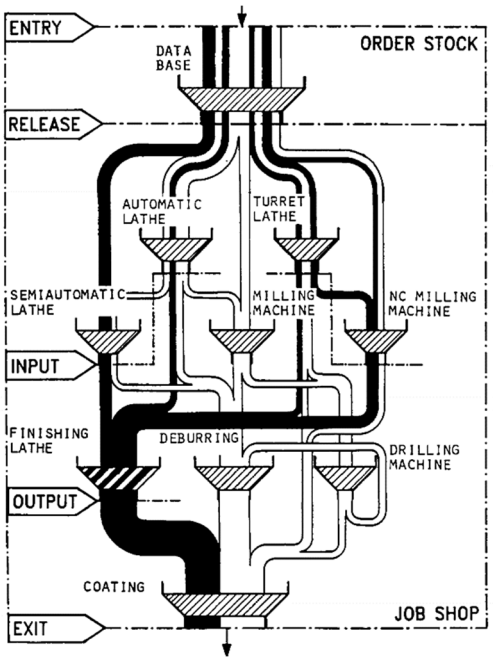


Figure 4.4 – Example figure from LOMC literature illustrating the flow of material through work stations in a manufacturing business (Bechte, 1988) in what is called the "funnel model" of a job shop.

4.2 Operations Management in Hospital

Now that OM has been presented in general terms, this subchapter will present what operational aspects and characteristics that are relevant for the management of the general hospital. First, this subchapter will present some basic aspects of hospital operations management to give a frame of reference necessary to understand the selection of methodology secondly this chapter will give the logical rationale for the choice of the specific method.

4.2.1 Operation Management in Health Care

Healthcare organizations have been lagging in the implementation of the different managerial methodologies that OM has to offer. This is not necessarily so much about the lack of

willingness on the part of healthcare managers but rather more attributable to the fact that OM-methodologies generally have lacked transitions to fit service-operations' particularities.

Hospital improvement has over the last decades almost evolved into its own field of science and in a large degree, crystalized itself apart from the general OM. This is due to the fact that health care is many fundamental characteristics is very diverging from the typical pure manufacturing companies. Mainly due to the fact that a hospital is publicly funded and the major complexity of the nature of the total operation that will be explained further in the theory chapter.

OM in hospital emerged from the evident improvement that the industry experienced from having a coherent and systemized approach for doing their business. It all started in earnest in the car producing industry with Henry Ford by organizing the manufacturing on an assembly line. The next section is going to illuminate the difficulties associated with the use of OM-methodologies in the public hospital sector.

4.2.2 Three barriers to Utilizing OM in the Public Hospital Sector

For full utilization of a particular OM-methodology developed mainly for the manufacturing industry to be fully utilized, there are three main barriers that need to be overcome:

1) The barrier of the particularities associated with *service operations;*

- → This is the barrier that comes with the territory when the organization deals with service as the primary output. Examples includes; one cannot simply build up a stock of produced healthcare that can be provided with a spike in demand (simultaneity), health care is hard to track and measure (intangibility), there is a big variability (some could argue infinitely big for health care) in customer need (heterogeneity).
- → This barrier is the most commonly permeated in the case of TOC as this has a vastly bigger marked, and there is a lot of examples to find in the literature (Cox & Schleier, 2010).

2) The barrier of the particularities associated with *health care;*

- This barrier is on the top of the first one as an additional layer. This barrier is that of health care operations nature is more characterized by work that craves soft aspects that the typical service company don't necessarily have to provide.
- Most of the reviewed articles in SUBCHAPTER 4.4 have gone through this barrier. However, they do not go through the next one.

3) The barrier of the particularities associated with *non-profit;*

- This is the barrier associated with the elements that are exclusive for non-profits or public tax-payer funding. The organization must organize the value-structure to accommodate deficiencies that are a result of the lack of the regulative force that a for-profit organization experience through their interaction with a competing market.
- As will be elaborated in SUBCHAPTER 4.4, this barrier is accommodated only by a small number of the articles written on TOC in hospital implementation. This dissertation's work is going to focus on permeate this last barrier (CHAPTER 5 and CHAPTER 6).

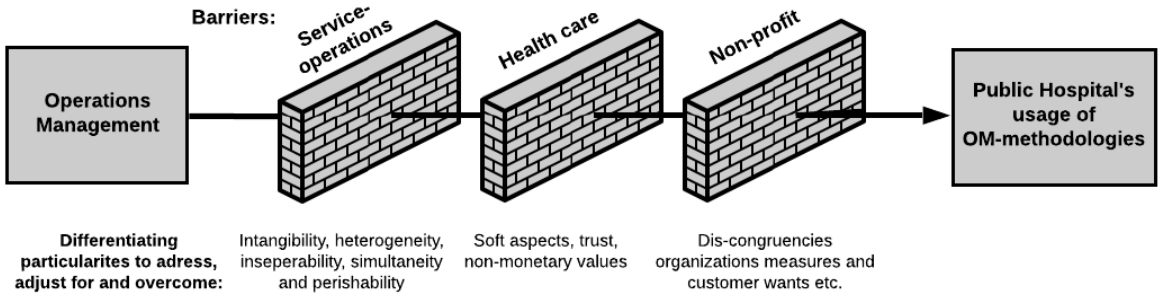


Figure 4.5 – The three main levels of barriers –with exemplified manifestations– to be overcome for a particular OM-methodology can have full utilization for the public hospital setting.

4.2.3 Operational Problems of Health Care

4.2.3.1 *The problem of Low Scalability*

The problem of low scalability is what is the common denominator for all specialized service companies. This encompasses the problems represented by simultaneity, heterogeneity, perishability. Low scalability denotes the fact that work performed cannot be distributed to a high number of recipients. As would be true for a product manufacturer or even more true for a software developer. Health care is used at the point exertion and cannot be stored etc. In the roam if hospital operations (or health care for that matter) this manifests itself through the newfound focus of patient-centric care, where the aim is to the greatest degree possible customize the treatment to each individual patient.

This "problem" is not so much one can do something to alleviate; however, it is instrumental to be aware of and to adjust the operation according to it to tackle its consequences. This problem, although present in the most service-based organization, is more damning for the healthcare sector than any other of the service-based type of organizations. Mostly, because the health care execution in a greater degree is a person to person service than any other (Cox & Schleier, 2010, p. 847)

Compared to the technology and software industry (in particular) a general increase in production scale in health care is a lot more predicated in a proportional increase in resource production factors. The limitations of scalability in health care appear due to the very nature of the very person-to-person (c.f. simultaneity) intensive interaction that is a crucial frame of condition that puts boundaries on the operation. Whereas software algorithm simply can be copied and sold across the world, or a manufacturing process may only need an increase in amperage to respond to an increase in demand. Conversely, an increase in demand for health care must be responded in an at least equal increase in the amount of workforce.

4.2.3.2 *The problem of Variability*

A hospital takes patients with huge varieties of conditions, where each of them acts differently on each individual patient. This problem is not fully exclusive for the health care sector, however, combined with the fact that there are a plethora of possible number courses of treatments for the largely accrued amount diagnoses. This variability gets multiplied with the variability caused by the variability of demand pattern. This, combined with the basic nature of

health care that constitutes than one cannot simply build up a stock which can be used to fulfill the demand whenever the demand rises.

4.2.3.3 *Problem of Silo-Mentality*

Silo-mentality is what characterizes the result of optimization in the within the different sub-units (e.g., functions, departments, wards) of an organization, in contrast, to optimize among them. An organization where the workers of sub-units focus on the optimization of their sub-unit rather than the entire organization will stagnate toward a state of sub-optimization (Ronen, Pliskin, & Pass, 2018, p. 11). Umble et al. (2006, p. 1062) list the silo-mentality as one of the three leading general causes of problems within healthcare systems generally.

In hospitals, silo-mentality is a state that happens when a hospital on the executive and operational levels get focused on the improvement within the, e.g. functions, wards, departments. Crawford-Mason (2002) writes the following in "Deming and Me" where Paul B. Batalden[5] problematize this concept;

> *"People in medical training are prepared to work in a silo when much of their work must be done outside their silos," he said. "Because of an ingrained silo mentality, they don't understand they are essentially interdependent and connected with all the other parts of the medical system. And they don't understand the patient or customer must be part of the system."*

As seen from FIGURE 2.1 in SECTION 2.1.1 the hospital is a type of organization that characterized with a great degree of communicative work, global cooperation, etc. across departments caused by the fact that patients have to go from function to function during the hospital stay. In the operation of the hospital, the silo mentality induces frequent organizational failures and contributes to unnecessary waste and delays (Umble & Umble, 2006, p. 1062).

4.2.4 Hospital Improvement

The aim of this subchapter is to describe hospital operation management concepts as it's from the perspective of operations management independently from the selected theoretical methodology chosen in this thesis. This subchapter will explain some conceptual and theoretical

[5] Paul B. Batalden, Senior fellow professor at IHI (IHI - Senior Fellows, n.d.).

frameworks from operations management that are used as tools for this TOC operations implementation into hospital management that is not necessarily part in parcel of TOC.

4.2.4.1 *Concepts and Qualities of Hospital Operation Management*

As eluded to in (SECTION 2.1.1); a hospital may be portrayed as a "system." A system is a collection of organized elements that are interacting in according to serve a function or purpose (Meadows & Wright, 2009). In this context, the system being a hospital the system contains elements such as nurses, doctors, wards, buildings, etc. and a purpose that we are going to analyze later in the thesis. One useful way of looking at a system as a processing unit that is treating inputs in a particular way for then to output something else. In the case of the hospital, the hospital is a system with workforce and budget as input while it outputs the health of the population.

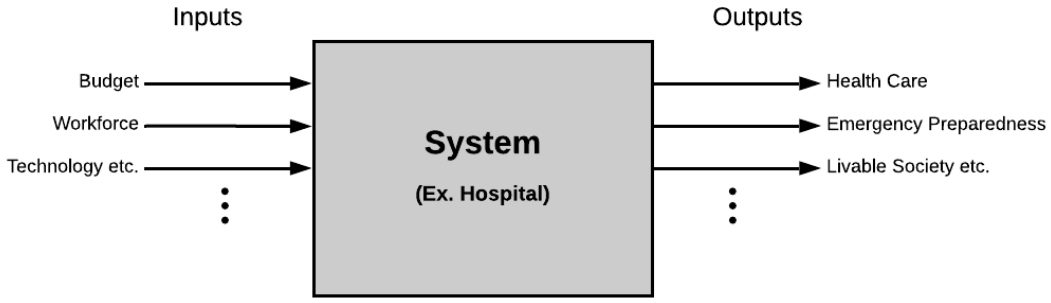


Figure 4.6 – Simplified illustration of the system-view exemplified with different input's and outputs. A hospital will non-monetary and intangible outputs of their organization.

4.2.4.2 *Constraint*

The hospitals' constraint is the one place that is restricting/preventing the system from keeping up with the supply to correspond with the demand. As we certainly know, the hospitals' demand for the different tasks/activities that are in the portfolio may vary vastly. Thus, the logical consequence is that the bottleneck might wander from one area to another

The term "system-view" is also used to refer to the focus on the whole system in contrast to having a focus on the small subparts within it this expression goes is seemingly adopted by the hospital improvement community as "hospital-wide." Through the times the most bedeviling aspect of the operations of a hospital is the lack of this exact such notion, the operations are

often characterized by silo-mentality which stands in direct opposition to the holistic system-view.

Patient-centric health care

Every patient treated by health care is one unique individual that needs treatment customized to the infinite particular need of the patient. As a logical consequence, each patient requires a tailored path in the system that is customized for the infinite particularities of that patients need.

The concept behind patient-centric healthcare acknowledges that each patient may have different treatment even when the same diagnosis is given. A logical consequence of embracing this notion has increased the variability of the treatment of each patient. This can be seen as the tradeoff between mass production and mass customization, which is a concept well known in operations management.

The Value Structure's Implications

About the last barrier in FIGURE 4.5; For-profits have the advantage of the economic pull to the orient towards the customer wants. This fact is very convenient because this provides regulation necessary the success. Every deviation from the customer wants will immediately result in the lowering of sales. Yet, this pull towards congruency (between organization operations and patient want) is removed in the case of non-profit and has to be stimulated in a clever way. This might be done by establishing values and a to aim for the corrective regulating force that would be present if the customer. This is further discussed in SUBCHAPTER 4.4 and addressed in CHAPTER 5.

4.3 Theory of Constraints

This subchapter serves two main purposes, apart from the fact that is undergirding the assimilation process by analyzing the theory. Firstly, it will provide the reader unfamiliar with the theory an entrance without having to look up auxiliary literature. Secondly, it serves the purpose of giving transparency into what is the taken presuppositions before the subsequent chapters is built upon. This gives the reader a good chance of scrutinizing the later development of the theory that is performed in CHAPTER 5.

This subchapter is divided into two parts, one that presents the literature TOC historical appearance (SECTION 4.3.1). The second part will give an insight into the theory itself (4.3.2-).

4.3.1 About the Theory of Constraints

Theory of Constraint is a system improvement methodology with complementary tools to achieve improved system performance of any kind of business or organization. It had its genesis through a concept known as optimized production management, and that served very well in the emergence of when companies could procure lower-cost computers. Out from this there was derived generalizable rules that and it flourished into the theoretical manufacturing philosophy we now know as Theory of Constraints (TOC) (III & Spencer, 1998, p. 2048)

About the Founder of TOC

The shoulders that this dissertation will stand on is in the largest part the ones of Dr. Eliyahu Goldratt. Goldratt is the one that in the late ’70s which in his work of creating what later would be called the Theory of Constraints. Goldratt, in turn, stood on the very shoulders of the Taiichi Ohno, the great father of Toyota Production, which now is popularized as Lean Management (Goldratt, 2006).

Eliyahu Goldratt (1947-2011) was an Israeli physicist, educator and business guru that dedicated his intellect to develop and invent several concepts within the field business management (TOC-Goldratt.com, n.d.) (Cox & Schleier, 2010). His original work contains several concepts that have been embraced in the business management community, i.a. Optimized Production Technique, the Thinking Processes, Drum-Buffer-Rope, Critical Chain Project Management, etc. (Shapiro & Dietz, n.d.). He wrote and published a total of 12 books, where he introduced these concepts and methodologies. His best-selling book is “The Goal – A Process of Ongoing Improvement” which has sold over 6 million copies and is one of the best-selling business books of all time. (Lang, n.d.; Shapiro & Dietz, n.d.; TOC-Goldratt.com, n.d.)

The Relevancy of TOC

TOC is regarded as a managerial breakthrough, and it has shown significant improvements in organizations all around the world (Ronen & Pass, 2008, p. 43). Also, it has been spread across several different enterprises, such as manufacturing, education, strategy, marketing health care,

research, and development. Even in psychological issues like helping prisoners addressing personal problems (Nagarkatte & Oley, 2018) (Cox & Schleier, 2010, p. 9). In 2007 it was estimated that TOC was applied in order to solve systemic issues and operate 15% of the world businesses (Nagarkatte & Oley, 2018, p. 11). Schaefers et al. (2007) even claims that "[TOC is] without any doubt, the most innovative management method or philosophy invented during the last century" and explains that this is interesting when one takes into account how much methods such as Just in Time, Total Quality Management, Business Process Management and tools like Six Sigma and lean manufacturing have had its time to compete and co-develop throughout time (Schaefers et al., 2007). Mabin & Balderstone (2003) reviewed articles in journals in excess of 100 (Umble & Umble, 2006). They reported an average increase in throughput/revenue/profit of 76%, raise in due-date performance on average 44% and decrease in inventory of 49% on the average (Umble & Umble, 2006).

4.3.1.1 *About the Book "The Goal – A Process of Ongoing Improvement"*

The book is an easy read book and doesn't have any prerequisite of understanding of how companies work. The book is carefully written in such a manner that the reader experience the problem-solving him- or herself (Goldratt, 1999). Allowing the reader to have the ownership of the problem get the reader a way to use the brain themselves to reach their own conclusions, the story and its development certainly grab the attention of the reader profoundly. Theory of Constraints emerged from the mentioned book called "The Goal" (Goldratt, 1984) written by the mentioned great author Eliyahu Goldratt. The book is written in a novel format as he explained was the only proper way to articulate the theory sufficiently.

The Goal describes a manufacturing setting where the manager, get the message of his nightmare; improve the income in the next three months or else the whole place will shut down and in turn lay off all his 600 co-workers. The book takes us through the journey of the manager where he, to his great shock, realizes that most of what the company does is counterproductive. This awakening made him realize that the numbers and performance measures used within the company too often has abstracted the business away from achieving their true goal and also too often used to wrong purpose, as winning small battles within the company and not for the sake of moving the company towards the true goal. The extracted theory of this book that moves the company towards the goal will be presented in the theory chapter.

4.3.2 The TOC-scope of this Dissertation

The scope of this chapter is not as wide as it typically would be in presenting the full theory, this is because the dissertation extent of this dissertation is limited to what will later be defined (SECTION 5.2) as "the core" of the theory. This core only concerns the central part and assumptions of the theory, namely the value structure. Therefore, to be concise and keep the dissertation focused (and keep the reader interest); just those part the theory that the later processed in the analysis (CHAPTER 5 and CHAPTER 6) is going to be concerned with will be mentioned here.

The full body of knowledge of the theory of constraints can be divided into three major parts; *the core*, *principle*, and *tools*;

Principles

TOC's body of knowledge is loaded with different conceptual principles. That appears both in the primary literature and secondary literature. A list of the most important principles of TOC is provided in SUBSECTION 4.3.2.1. The fact that TOC consists of a substantial portion of principles are the reason why the author chose to present the theory in a narrative format as some of them seems odd and counterintuitive.

Tools

In addition to the principles, TOC's body of knowledge consists of tools such as throughput accounting, the thinking process, buffer management (drum-buff-rope), and critical chain project management. The hallmark tool of TOC is definitely the five focusing step, which is going to be presented in SECTION 4.3.5 and going to be used illustratively to substantiate and validate the transformed framework in SUBCHAPTER 6.3.

The core

The core represents the TOC's proposed value structure; the goal and its measures. This is the main part that is going to presented and be subject for modification, transformation, and implementation (CHAPTER 5-6). The reason why this is the subject of transformation is more elaborately described in the start of analysis (SUBCHAPTER 4.4 and 5.1). This value structure is presented in this chapter's SUBSECTION 4.3.4.

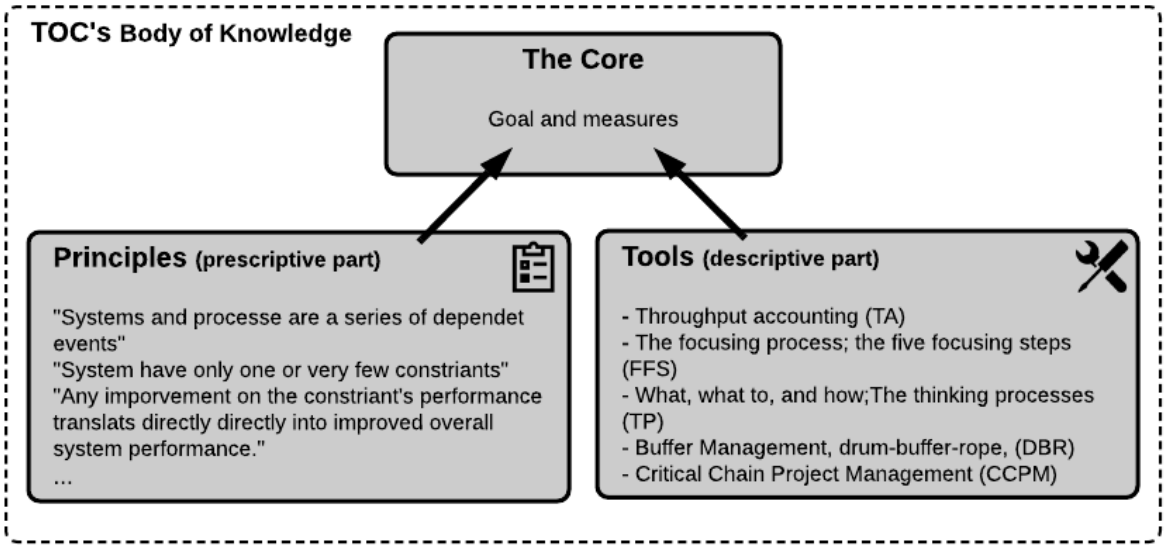


Figure 4.7 – Map of the constituent elements of TOC; the core, principles, and methods. The hierarchical placement of these parts is going to be discussed in SUBCHAPTER 5.2.

4.3.3 The Fundamentals of Theory of Constraints

The great strength of TOC compared to methods like Lean Management and Six Sigma is that instead of improving the system (with regards to waste and precision) across the board one will instead focus down on the most impactful constraint hindering the overall productivity of the organization and alleviate that above anything else. One of the major theses of TOC is that a company have only one or just a few constraints (see SUBSECTION 4.3.2.1). The constraint is whatever that hinders the company from reaching its overarching goal.

Another clear distinction from the other philosophies is that instead of focusing mainly on reducing operating expenses, TOC has that only as a secondary concern. The primary focus is instead to raise the production, which in fact will raise the operating expenses, albeit also raise the revenue if it covers the demand from the customers.

TOC promotes the very concept of thinking logically and is critical to the established truisms that maybe once have held true for a certain situation but might not be true in every case. The theory as it gets laid out in “The Goal” promotes critical thinking. This gets illustrated in a very good way in the 4th chapter when the main character, Alex Rogo, meets Jonah – his Physics professor from college. Smugly Alex wants to show how well he is doing with the procurement of the new high-tech robot in his factory assembly line. Little does he know that Jonah has

studied business management quite well and is able to reveal Alex's factory is not going as well as Alex makes the impression to be. Following is an excerpt from the book (Goldratt, 1984);

Following is an illustrative excerpt from Chapter 4 in "The Goal – A Process of Ongoing Improvement" (Goldratt, 1984, Chapter 4);

> *But when I look back to him, Jonah doesn't seem very impressed. I figure, well, he's an academic person; he's not going to understand the business world. "You say your plant uses robots?" he asks. "In a couple of departments, yes," I say. "Have they really increased productivity at your plant?". "Sure, they have," I say. "We had—what?" I scan the ceiling for the figure. "I think it was a thirty-six percent improvement in one area.". "Really . . . thirty-six percent?" asks Jonah. "So, your company is making thirty-six percent more money from your plant just from installing some robots? Incredible.". I can't hold back a smile. "Well . . . no," I say. "We all wish it were that easy! But it's a lot more complicated than that. See, it was just in one department that we had a thirty-six percent improvement." looks at his cigar, then extinguishes it in the ashtray. "Then you didn't really increase productivity," he says.*
>
> *I feel my smile freeze. "I'm not sure I understand," I say. Jonah leans forward conspiratorially and says, "Let me ask you something—just between us: Was your plant able to ship even one more product per day as a result of what happened in the department where you installed the robots?". I mumble, "Well, I'd have to check the numbers . . .". "Did you fire anybody?" he asks. I lean back, looking at him. What the hell does he mean by that? "You mean did we lay anybody off? Because we installed the robots?" I say. "No, we have an understanding with our union that nobody will be laid off because of productivity improvement. We shifted the people to other jobs. Of course, when there's a business downturn, we lay people off.". "But the robots themselves didn't reduce your plant's people expense," he says... "No," I admit. "Then, tell me, did your inventories go down?" asks Jonah. I chuckle. "Hey, Jonah, what is this?" I say to him. "Just tell me," he says.*
>
> *"Did inventories go down?". "Offhand, I have to say I don't think so. But I'd really have to check the numbers." "Check your numbers if you'd like," says Jonah. "But if your inventories haven't gone down… and your employee expense was not reduced . . . and if your company isn't selling more products—which obviously it can't, if you're not shipping more of them—then you can't tell me these robots increased your plant's productivity."*

One thing to keep in mind is that the full theory was not presented in this first book. **The Goal** only presented an introduction to the basic principles and cannot be regarded as a complete

presentation of the total body of knowledge. The theory has since its conception been a work-in-progress, and the most complete work of gathering all parts of the theory is found in "*Theory of Constraints - Handbook*" (Cox & Schleier, 2010).

4.3.3.1 *Principles of TOC*

A big portion of TOC's body of knowledge consists of principles that are helping to conceptual interpretation of the system and how to understand it. Dettmer has made a list of some principles that is placed in the below figure (Dettmer, 1997).

- Systems thinking is preferable to analytical thinking in managing change and solving problems.
- An optimal system solution deteriorates over time as the system's environment changes. A process of ongoing improvement is required to update and maintain the effectiveness of a solution.
- If a system is performing as well as it can, not more than one of its component parts will be. If all parts are performing as well as they can, the system as a whole will not be. THE SYSTEM OPTIMUM IS NOT THE SUM OF THE LOCAL OPTIMA.
- Systems are analogous to chains. Each system has a "weakest link" (constraint) that ultimately limits the success of the entire system.
- Strengthening any link in a chain other than the weakest one does NOTHING to improve the strength of the whole chain.
- Knowing what to change requires a thorough understanding of the system's current reality, its goal, and the magnitude and direction of the difference between the two.
- Most of the undesirable effects within a system are caused by a few core problems.
- Core problems are almost never superficially apparent. They manifest themselves through a number of undesirable effects (UDEs) linked by a network of cause and effect.
- Elimination of individual UDEs gives a false sense of security while ignoring the underlying core problem. Solutions that do this are likely to be short-lived. Solution of a core problem simultaneously eliminates all resulting UDEs.
- Core problems are usually perpetuated by a hidden or underlying conflict. Solution of core problems requires challenging the assumptions underlying the conflict and invalidating at least one.
- System constraints can be either physical or policy. Physical constraints are relatively easy to identify and simple to eliminate. Policy constraints are usually more difficult to identify and eliminate, but removing them normally results in a larger degree of system improvement than the elimination of a physical constraint.
- Inertia is the worst enemy of a process of ongoing improvement. Solutions tend to assume a mass of their own that resists further change.
- Ideas are NOT solutions.

Figure 4.8 – TOC's body of knowledge contains normative principles. Dettmer (1997, p. 12) provides one of the most concise and comprehensive collections of these principles.

These principles have consequences that might give a new perspective on established measures that have more or less had their intuitive interpretations;

4.3.3.2 *The Constraint of a System*

The system itself is the organization that is subject to improvement. The system might be a for-profit, not-for-profit, educational, environmental, etc. organization. Generally, these systems have aims in mind, reasons to exists to why they were created. The definition of constraint within regards to TOC is the one factor that if increased, would raise goal achievement.

Different Types of Constraints in the system

As elaborated in the early literature (Goldratt, 1984), each system has one or at least very few constraints. The constraint might variate along two dimensions; location and physical manifestation.

- Location range from specific location inside the system to outside of the system; either before (suppliers) or after system (demand/customer).
- The physical manifestation ranges from; mechanical constraint to general conditions surrounding the operation; e.g., policies (external or internal), general knowledge within a specific field of knowledge, etc.

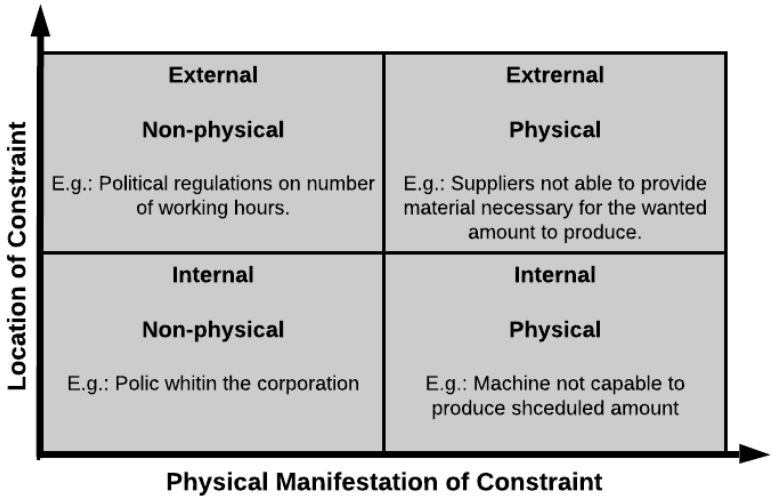


Figure 4.9 – Illustrative conceptualization of the different types of constraints that can appear in an organization, with examples of the four different types of general categories of constraint.

4.3.4 *Determining the Global Goal*

Time has proven that every organization that wants to stay in operation has to change over time. Thus, every organization that wants to thrive and don't want to remain stagnant should have a goal to change according to. For a manufacturer, this aim should be something as "staying in business," implicitly this means to make money. A business that does not make money can't pay salary to its employees nor buy in raw materials; without making money, the business will not survive.

The goal is and should be perceived the overarching low-resolution measure that is such as that can be used to derive guidelines from underpinning the goal. Good quality of a goal is that it should never be fully attainable so that the endeavor is always aspiring to continuous improvement (Ronen et al., 2018). E.g., for most private companies, this overarching low-resolution goal is to maximize the long-term profits.

The goal is the fundament for all the operational measures that will be taken. To verify if a measure is productive according to the goal, one must verify that the measure moves the company in the direction of the goal. However, out from this goal, one has to derive higher resolution measures that we know we can operate on so that it's more concrete and approachable.

4.3.5 *Global Performance Measures*

To achieve the mentioned overarching low-resolution goal, an organization has to operationalize this. One of the major tenets of TOC is that this is done through three global performance measures.

In the aftermath of the concretizing of the company's goal in "The Goal – A process of Ongoing Improvement" (Goldratt, 1984) the main character deduces two sets of global performance measures; one set financial performance measures (FGPM) to tell if the manufacturing company is underpinning the goal seen from the financial perspective and one set with operational global performance measures (OGPM) to tell if the manufacturing company is underpinning the goal seen from the purely operational perspective.

The following subsections will first go through and explain the FGPM, then the same for OGPM and lastly the relation between them will be presented and summarized. The measures

will here be presented as in the context that the book presents, i.e. of a traditional pure manufacturing company.

4.3.5.1 *The Financial Global Performance Measures (GPMs)*

The GPMs is a first level derivation of the global. The reason for having them is to express the goal in a more concrete manner and tell what to do in order to move towards the agreed upon goal. Following is a list the explanation of the three financial global performance measures *cash flow*, *net profit,* and *return on investment*.

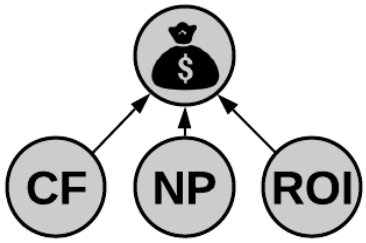


Figure 4.10 – The financial global performance measures (FGPM) cash flow, net profit, and return on investment in combination serve (in sum) as proxies for the goal in the financial roam for the overarching goal.

Cash Flow (CF) – Is what money is realized through the sales of products, i.e., revenue. It would be the normal condition for a company to generate sufficient cash flow in order to manage the short-term expenses. However, if this is not true, the company can't make the necessary short-term investment to pay for workers, inventory (i.e., the current expenses). Put another way; this is available capital for the further short-term operation of the factory. Bad CF is what kills most of the companies that go under (Goldratt, 1984). Cash flow is generated by sales of processed raw materials, and it may be decomposed into two subcomponents; selling price and quantity sold.

Net Profit (NP) – From the pre-supposition that the goal is to maximize the profit we can by this logically say that every amount of money in is a contribution towards the goal. To even be on the path of maximizing profit, one also need as a pre-requisite to have a positive net profit. This means; selling the products made for more than what was paid for making it (NP =

Revenue – Expenses alternatively; NP = T – OE). NP serves as an indication of the total revenue is greater than the total expenditures.

Return on Investment (ROI) – To tell how "good" we have accomplished the fundamental measure, net profit, we evaluate it concerning the what invested in the making that profit. This measurement is giving information on "how good" the performance is given what was invested in making it. In other words, how effective is the investment given the operation of the production (ROI = NP / I).

Summary of the FGPM

The FGPM seems quite trivial to figure that is in the best interest of the company. However, what is not so obvious is the fact that these are the only measures a manufacturing company has to know in order to evaluate if the company is moving towards its goal or not. Even if only one of them is improving while the other is ,held fixed, the company is then doing better, according to TOC.

4.3.5.2 *The Operational Performance Measures*

Just as the FGPM, the OGPM serves collectively as a proxy for the goal into the roam of operations of the manufacturer.

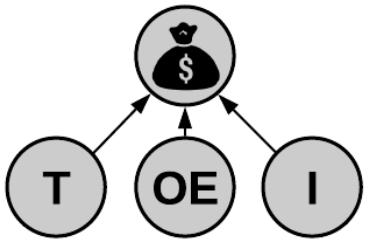


Figure 4.11 – The operational global performance measures (OGPM); throughput, operational expenses, and inventory in combination, serve as proxies in the operational roam according to the overarching goal.

Throughput (T) – In the case of a manufacturing business, throughput is the measure of finished products produced that gets *sold* to a customer. The important word here is "sold"; as long as the product gets produced (or partially produced) but lies around in along the production line

or in the storage and do not have an intended paying customer, it is not to be regarded as a step in the positive direction according to the goal. Depending on the situation, it will be counter-productive cf. the goal, as it will cost workmanship to place it into storage. The unsold units will lower all of the GPM's and hence do the business further away from its goal. Throughput expressed as a rate within a predefined time interval and can be decomposed into the number of units and the sale price (e.g., x-USD a day, month, etc.) and is calculated as sales minus variable cost (OE).

Operating Expense (OE) – Jonah puts this measure concisely in "The Goal" where he explains that OE is all the money that is used to turn the inventory into throughput (Goldratt, 1984).

Inventory (I) – Is "[the cost of] everything that the system has invested in purchasing things which it intends to sell" (Goldratt, 1984), i.e. the cost of the work-in-progress on the assembly-line and whatever work-in-progress that might be kept in the at the assembly line or ingoing or outgoing stock. This is heavily dependent on how the factory is configured; however, it is in the interest to minimize this to the lowest practical point.

Summary of the Operational Global Performance Measures

These measures explain how the business should go about put in operational terms. The claim is that everything that one can manage in the factory, in relevance to the goal, is covered by these three measures (Goldratt, 1984, p. 67). Throughput is preferred to be raised everything else fixed, inventory is preferred to go down everything else fixed, and operating expenses are preferred to go down everything held equal.

4.3.5.3 *Summary of the FGPM and OGPM*

In "The Goal" (Goldratt, 1984), it is claimed each one of the sets (FGPM and OGPM) can function as the governing independently. However, FGPM is explained in terms easier understood by the financial manager, and OGPM is easier understood by the job-shop manager. Reverting back to the system view (illustrated in two versions SUBCHAPTER 4.1 and 4.2), the following figure illustrates this claimed isomorphic relation:

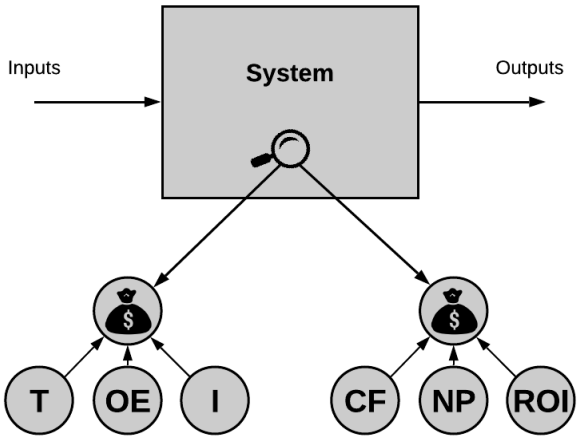


Figure 4.12 – The two sets (FGPM and OGPM) has an isomorphic (i.e., they tells the same only in two different perspectives) relation of according to the system.

4.3.6 Example – Illustrating Five Focusing Steps and the OGPM

From the previous subsections, it might be a hard thing to swallow that only three measures are sufficient actually give a full picture of the situation in the manufacturing company. This example shows the solid imperviousness (i.e., ability to capture *everything* that is of importance) of the measurements. The five focusing steps are also emphasized here because it is also demonstrated at use in SECTION 6.3.1 – SECTION 6.3.4 when implementing the value-structure of TOC in the setting of a publicly funded hospital.

4.3.6.1 *The Three Major Questions*

There are three main questions put forward by TOC, which are proposed to find the answer to, and they are fundamentally incorporated within the five focusing steps. The fundamental questions to be asked is the following:

The three main questions of ToC;

- What to change?
- What to change to?
- How to cause the change?

The main tools that is made for answering the question are those encompassed in the Thinking Processes. However, they get also addressed by and large in proposed Five Focusing Steps (FFS).

4.3.6.2 *The Five Focusing Steps*

The FFS of TOC were articulated right beginning, as it was presented in "The Goal" (Goldratt, 1984). "The Goal" presented the focusing steps as a list of 5 steps, some in the ToC-community likes to include the goal setting and establishment of performance measures as steps and thus present the focusing steps as a 7-step list (Ronen et al., 2018). This hypothetically could have its strengths if one operates in a fast pacing industry or where the law- and political forces often perform radical changes where the goal itself might change to a considerable degree. Since the goal and the performance measures (FGPM and OGPM) already is presented, the FFS will in this work be presented in its original 5-step format.

The list of the five steps should be regarded as a general algorithm. And the backside of the coin of a general algorithm is that the steps within will not always fit in every situation and some steps may in certain situation not be applicable.

The Five Focusing Steps;

1. *Identify* the constraint in the system.
2. *Exploit* the constraint.
3. *Subordinate* rest of the system to the constraint.
4. *Elevate* the constraint in the system.
5. *Repeat* the process from step 1.

The figure following below is made for illustrating the steps as a perpetual process. As we see from the process depiction, this process has a recursive pattern. This is an important part in to promote the notion of having the organization to constantly and continually have an ongoing improvement process.

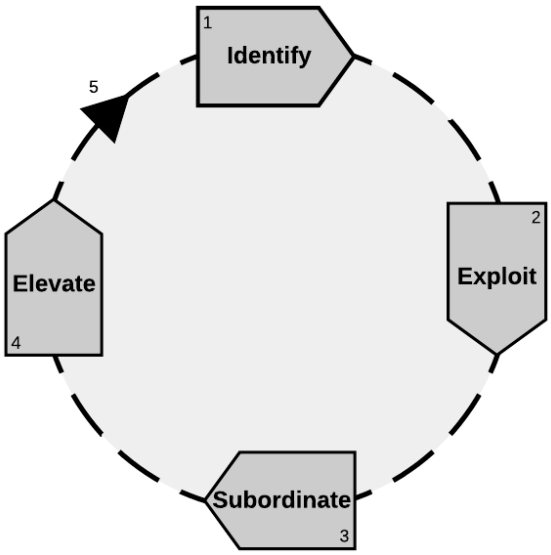


Figure 4.13 – The FFS; Identify, Exploit, Subordinate, Elevate, and Repeat, suggesting a perpetual process of continual improvement for the organization (Pretorius, 2014).

4.3.6.3 *Exemplification of the GPM's through the Five Focusing Steps*

This subsection is going to concretize these somewhat abstract steps presented through the context that is most classical for this theory; the pure manufacturing setting. The reason why this was the chosen context is primarily that it is easy to understand and secondarily because it is one of the few cases where most of the steps are appropriate and legitimate justification to be carried out.

For the sake of the example, let us say that there is a manufacturer that is processing raw material through three separate processes and that it outputs a type of processed good, for sale to its customers. The following figure presents a low-resolution that the consecutive figures presents further details relevant to display the relevant mechanics throughout the use of FFS.

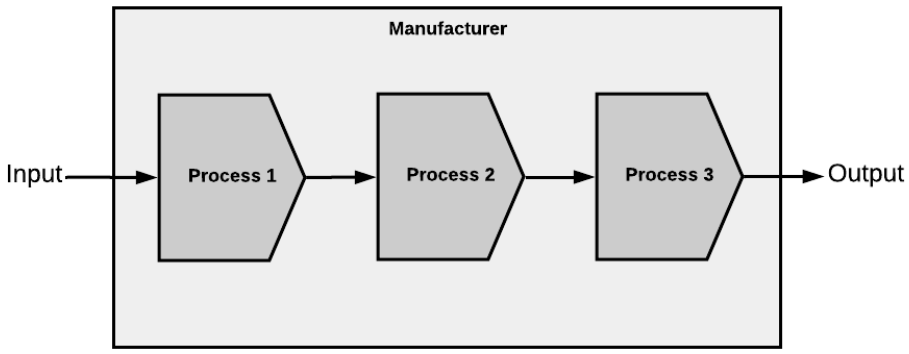


Figure 4.14 – Ill. presenting example use of the Five Focusing Steps. A manufacturer that process raw material in three distinct steps before selling to receiving a customer.

The following subsection is explaining the unfolding of the different steps of FFS and how they impact the organization through the performance measures:

Step 1: Identify

This step might be the most demanding and time consuming to figure out. It is not obvious what is a constraint. However, to be strictly obedient to ,TOC is that object that is hindering the throughput the most. So as suggested in "the Goal" (Goldratt, 1984), this might be the place where inventory is stacked in a disproportionate proportion. The below figure presents a way to ease the process of identification by mapping out the processes. And investigate what the actual capacity (cap.) is and how much gets produced (prod.) in each of the different processes in the manufacturer. In this setting, a cardinal indication of a constraint is looking at accumulated inventory. In another setting aside from manufacturing, where inventory is not that obvious, mapping out the capacities and production amount might be the only way to identify where the constraint lies clearly.

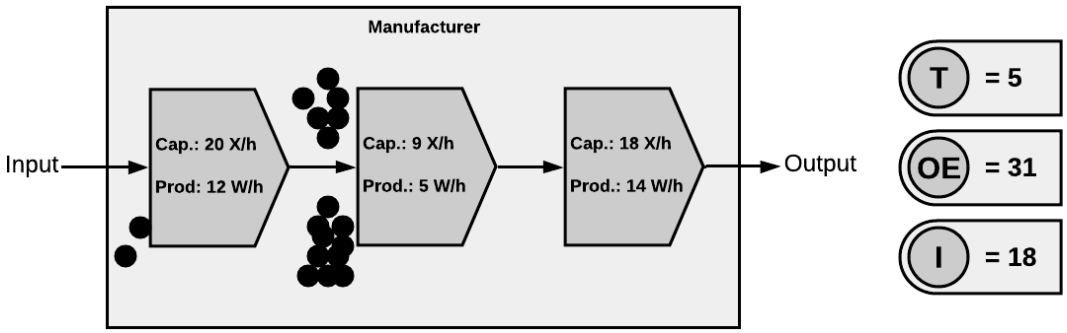


Figure 4.15 – Identification of constraint involves mapping out the processes of the manufacturer with the capacities (cap.) and produced capacity (prod.).

In the figure; production capacity (prod.) is contingent on the designated resources, e.g.; the number of workers to the individual processes, the upper limit is the process capacity (cap.).

Step 2: Exploit

The exploitation is to recognize that the constraint is, in fact, present and that the overall productivity of the total factory will not improve until this is managed. Any excessive capacity that exists before or after this in the stream of throughput will necessarily be redundant. Any production that surpasses that of the constraint will yield an abundance of inventory and unnecessary cost associated with those processes. Thus, one way of exploiting this is to reduce the capacity of the preceding, and subsequent processes as these might have an unnecessary high capacity that could reduce the operational costs if were only used in the .

In the example, a good exploitative action as we pretty obviously see is that the intensity of “Process 1” can be significantly turned down. Having all these workers focused on this high production causes unnecessary inventory stacks up. We see now that this making “Process 1” run at this high capacity causes two expenses that can be regarded as direct operational cost; idle time and inventory. Hence it makes the total factory operation more efficient just by cutting down this capacity.

The exploitation step is heavily dependent on the particulars of the situation. One would simply not fire the employees in the surrounding processing tasks if step 4 would be implemented fairly quickly.

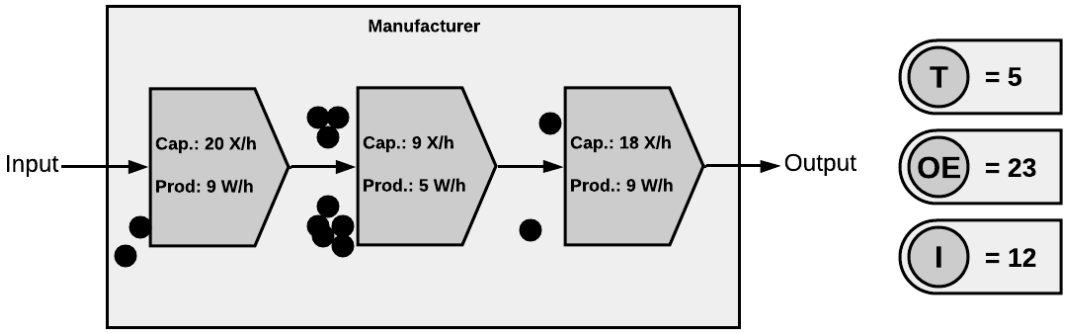


Figure 4.16 – Exploitation of the constraint; there recognize that there is no point in producing more than what is the maximum capacity of the "weakest link" of the processes.

Step 3: Subordinate

This process is in part about making everyone in the factory that is has work associated with the constraint know and cautious of the fact that is the limiting constraint on the business improvement. And by that fact doing actions to make sure that that the constraint is working at is full capacity with no breaks. By simple logic, the whole factory will not be more productive than this what this machine (chain analogy; the chain is not stronger than its weakest link).

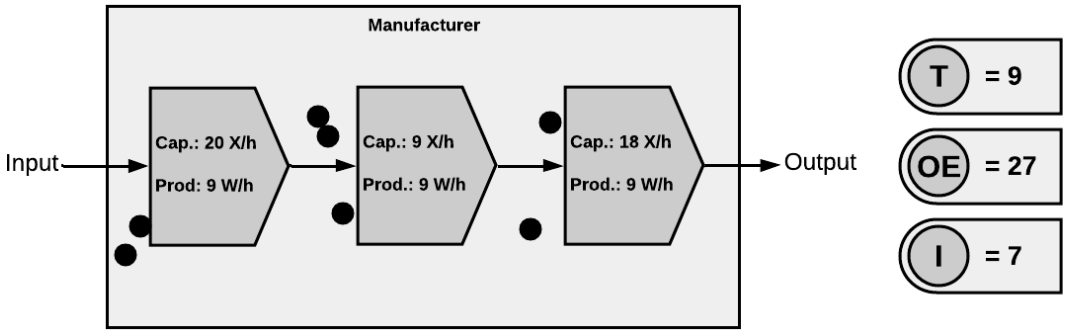
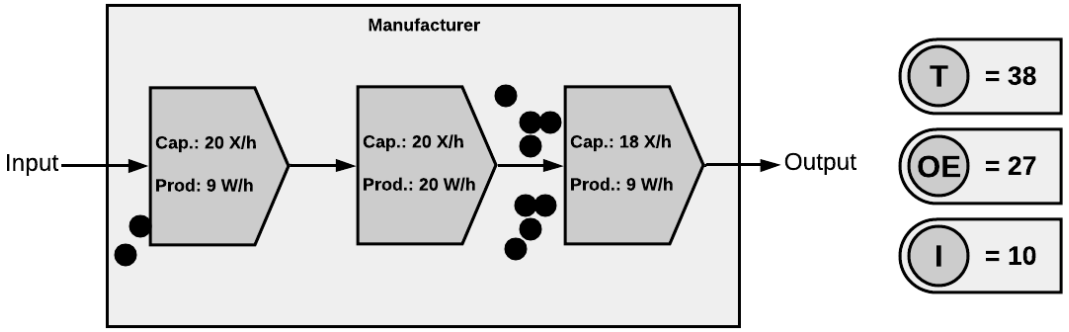


Figure 4.17 – Subordination; shift the internal resources so that the constraint has no idle time. Idle time in the constraint is idle time for the whole manufacturer.

The desired outcome from the subordination is to reduce the idle time of the constraining process so that its full potential can be exploited maximally. Also aligning the processes' capacity (cap.) of the processes makes it so that it gets possible to reduce the inventory to a bare minimum.

Step 4: Elevate

This process is to seek any ways of reducing the constraint; this could be done by enhancing the machinery or maybe invest in a new machine so that this process no longer is a constraint. By doing this, and if truly this is the constraint, the added capacity would amount the total factories' increased capacity all the way until there is emerging a new constrain another place in the factory.



Step 5: Repeat

If the identified constraint is not anymore the prevalent constraint of the manufacturer, one should go back to step 1 and follow the procedure for the next identifiable constraint.

One difficulty here is that depending on the inertia of the factory, one needs to let the new operation stabilize after the improvement. One could imagine environments where the workers take a longer time to adjust themselves for the new operation.

4.4 Critique of Past TOC-Implementations

The consulted literature pieces have consisted of books and scientific articles ranging the following fields and subjects such as; Theory of Constraints, Operations Management, Hospital Management, Innovation Management, General Semantics. The gist of this dissertation has been based on two first-mentioned subjects, and it is the conjunction of these that is subject for examination in this review.

In the appendix, the review of the scientific articles, either discussing, summarizing or adapting TOC in the healthcare setting is documented along with the categorization (SUBCHAPTER APPENDIX A.2).

4.4.1 Categorization of the Articles

For systematization of the articles reviewed, it was important to formulate categories that distinguished the past work in a useful way. The past subchapter (SUBCHAPTER 4.3) have demonstrated several distinct aspects of the traditional TOC. However, as will be reverted to, it is not a straight-forward endeavor to implement TOC in a healthcare organization, especially a publicly funded (mostly due to the challenges presented in the last barrier of the OM-transformation barrier presented in SUBCHAPTER 4.2).

Because of this, it was decided to categorize them so it would be easier to know better, which was along the line of this work (of this dissertation) and which was not. The categorization considers the scope of application of theory. This can be divided along two dimensions; the scope of the theoretical depth of TOC that was applied and what scope of organization-wideness of TOC was applied. Following is the qualitative definitions and their ascribed criteria.

4.4.1.1 *Quality of Selected Theoretical Depth*

Reading the past studies revealed the impression of a lack seems like there have not yet been made a clear the distinction on the different reach of applications. To “apply TOC” seems to vary in meaning. Ranging from “Using some of the TP-tools to solve a surface problem,” “Using TOC as the fundamental governing the decisions at every level of decision making (from the local micro level to the global macro decision).” The former is what would characterize a tool-, surface-, or problem level application. The latter is an example of what

would indicate a core level implementation, where the full value structure is implemented (as presented in SECTION 4.3.3 and 4.3.4).

- **Tool-level**; Methods, tools, or principles was used for the initiative documented in the work of the article.
- **Core-level**; The goal definition (or a modified version) and performance measures were taken into consideration in the work of the article to verify the initiatives' outcome.

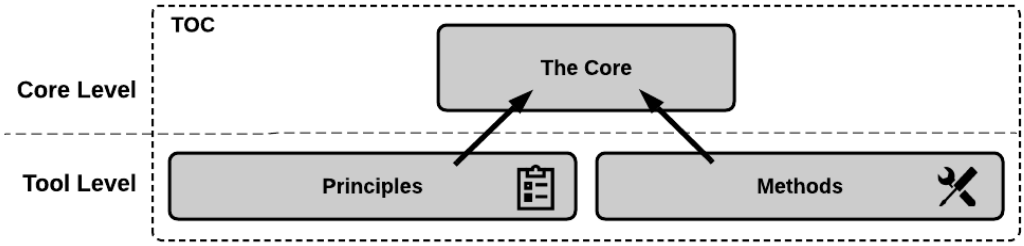


Figure 4.18 – Ill. the differentiation between Core Level and Tool Level implementation of TOC. An explanation of what is here regarded as core level is to be found in (SECTION 5.1.1)

4.4.1.2 *Quality of Level of Organization-wide Application*

It was found necessary to also distinguish between the level of application in the organization. The reason for this is that, as explained in (SUBSECTION 4.2.3.3) the silo mentality is bedevilment that has been shown to be very detrimental, and a local (e.g., ward, function, project) application might enforce this; system-view / silo mentality. A global level implementation should result in a change in every decision at every level of the organization from everyday micro-decisions to big strategic decision at the administrative level. Such an implementation would necessitate a mind-change for all the agents in the organizations and should not limit itself to only a single project or only one type of problems.

The tendency reflected in these reviewed studies of TOC implementation in hospital settings, as there was little concern of taking organization-wide initiatives. There was made no explicit distinction of various levels of application. TOC strives to take the role of being the guiding compass for the totality of the organizations and not a few departments, functions, or projects. Using TOC in only a portion of the organization is will just improve the individual local department, which is the silo-optimization, which is counter-productive. Following are the two

criteria used to establish if an article was focused on implementation in the local- or global level.

- **Local level**; The application of TOC described in the article was performed in a specific process, ward, function, i.e., sub-part of the organization, in contrast to the;
- **Global level**; The application of TOC described in the article was performed or aimed not only for a few processes, wards, functions, etc. but was aimed to use throughout the organization.

Categorization Matrix

These two qualities presented (i.e., selected theoretical depth and level of organization-wide application), makes up four different combinations. The matrix that constitutes the outset for the following categorization is presented in the following figure.

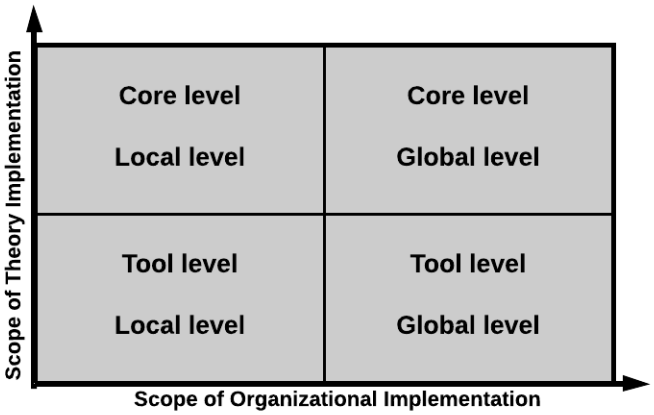


Figure 4.19 – Matrix of the different categories of articles in the literature search. Divided along the two dimensions “Scope of Organizational Implementation” and “Scope of Theory Implementation.”

4.4.2 Result of the Categorization of the Reviewed Articles

Following is the result of the categorization of the reviewed articles. First is a table presenting the different articles and their placement in the above-mentioned matrix. Problematization of implementation is found in the subsequent section (SECTION 4.4.3)

Table 4.2 – Resulting table from the categorization of the articles reviewed on TOC implementation in the health care sector.

Category	**Article** (author(s), year written)
Tool / Local Application in the articles concerns tool-level implementation at a local level (i.e., function, ward)	(D. E. Womack & Flowers, 1999), (Roybal, Baxendale, & Gupta, 1999), (Hunink, 2001), (Rotstein et al., 2002), (Rotstein et al., 2002), (Patwardhan, Sarría-santamera, & Matchar, 2006), (Umble & Umble, 2006), (Mast, Kemper, Does, Mandjes, & Bijl, 2011), (Mur-Veeman & Govers, 2011), (Schrijvers, van Hoorn, & Huiskes, 2012), (MacDonald et al., 2013), (Sahraoui & Elarref, 2014), (Verma et al., 2014), (Trickey & Newburn, 2014), (de Souza, Souza, & Vaccaro, 2016), (Aguilar-Escobar et al., 2016), (Leskela et al., 2016), (Pawlak, 2016), (Pergher, Brandolf, Pacheco, & Vaccaro, 2016), (Rawson, Kannan, & Furman, 2016), (Nestsiarovich et al., 2017), (Criddle & Holt, 2018), (Huang, Chen, Liu, Chen, & Chen, 2018), (V. Mabin, Yee, Babington, Caldwell, & Moore, 2018), (van Harten et al., 2018)
Tool / Global Application in the articles concerns tool-level implementation at a global level (i.e., the whole or several parts of healthcare organization)	(Wu, Jia, Liu, & Qi, 2009), (Stratton & Knight, 2010), (Cattaneo & Bassani, 2016), (Groop, Ketokivi, Gupta, & Holmström, 2017)
Core / Local Application in the articles concerns core-level implementation at a local level (i.e., function, ward)	(M. Gupta & Kline, 2008), (Kemper & de Mast, 2013)
Core / Global Application in the articles concerns core-level implementation at a global level (i.e., the whole or several parts of healthcare organization)	(Tomolo, Burton-Houle, & Aron, 2002), (Schaefers et al., 2007), (Sadat et al., 2013), (M. C. Gupta, Bridgman, & Kaur Sahi, 2015)

Following are two diagrams illustrating the quantitative result of the review of the articles in the literature review. As we quite clearly see, the predominant category is that of tool-level implementation at the local level.

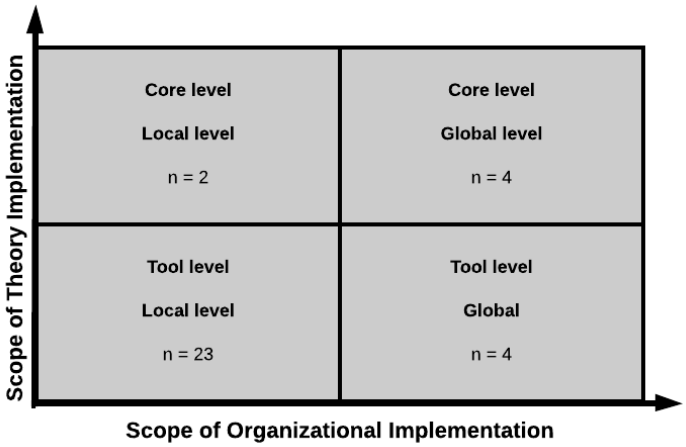


Figure 4.20 – Diagram plotted the counted amounts of the different categories of articles in the review.

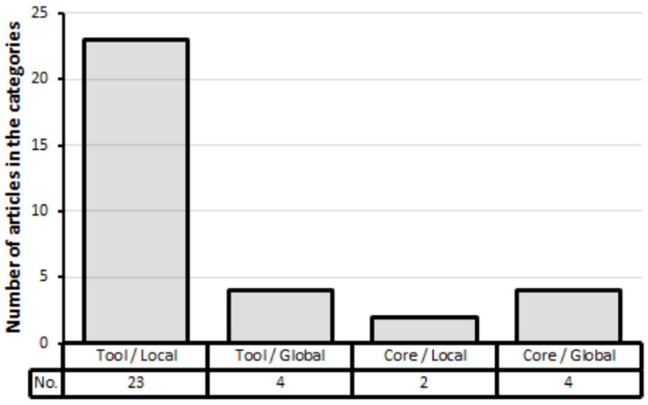


Figure 4.21 – Illustration of the articles written on the subject. The category partition with most articles was found to be the one based on tool level implementation on a portion of the organization.

4.4.3 Summary of the General Literature

There was a great diversity of application among the different literature articles found. However, as indicated, most of the applications were made in the smaller portions of the organization in contrast to performing in the whole organization. This is understandable since it's hard to gain acceptance to execute a program on the full operation. Yet, by doing this, one could compromise the effect the theory could wield by not taking the full advantage that a large scale implementation would yield. And it might be impossible to validate if the initiative was productive or not in hindsight. This is because of what is explained in the presentation of the value structure (SECTION 4.3.3 and 4.3.4).

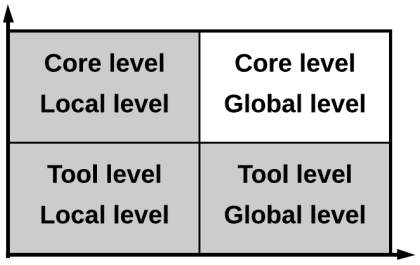


Figure 4.22 – Diagram showing the types of articles the summary of SECTION 4.4.3 primarily entails.

Even though an article falls under the categorization of tool-level implementation does not mean that it should be totally dismissed as it may provide valuable insight on the implementations on the concrete and situation specific level in cases where sufficient underlying documentation of approach is provided. Another thing to mention here is that those articles could have been written from a holistic rationale, but that the authors with their reasons (e.g., brevity, concise) omitted the explanation of the linkage to the holistic core level. Those articles could be valuable in case specific implementations.

Non-profit organizations it is very important to have a clear definition of what the goal is. However, it seems to be difficult just to do that, as these articles don't mention an overarching goal used for global and local decision-making.

There are three types of paradoxes in this type of implementation mostly leads to;

1) If one parameter is focused and no one of the other gets controlled for, the initiative might have resulted only in a new mix of the different parameters. This type is caused by not using the core in the first place, as the usage of the core would constitute the premise that all the parameters where considered ex-ante the initiative.

2) Other functions might be compromised because of the initiative, so even though great results have been measured on the object of improvement. Lack of global attention leads to a futile result as there is no way to know if the initiative is a net gain or loss.

3) Articles that have "optimized" one treatment may have done this on the expense of system-optimization (local optima is in direct conflict to global optima) no article that performed process-optimization did fully investigation if that process was the organization's constraint according to what TOC states in the literature. This may indeed be a testimony for the silo mentality that is so prevalent in this sector.

4.4.4 Review of literature at Global-Core Implementation Levels

The literature found to be categorized in the "Core/Global"-quadrant will be here given extra scrutiny as this is the literature that functions as the precursor of the present work entailed in this dissertation. As presented in the (SECTION 4.4.2), there was a minority of the literature that fall into this category.

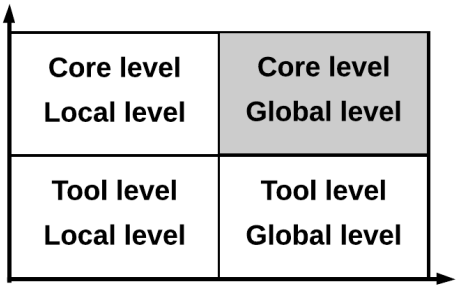


Figure 4.23 – Diagram showing the types of articles in this summary of the literature. This is the portion of the articles that is in special interest considering the further work of this dissertation (CHAPTER 5 and CHAPTER 6)

4.4.4.1 *Tomolo, Burton-Houle, & Aron (2002)*

This article is a well-cited[6] piece. A thorough description of some of the tools and principles that exist in TOC body of knowledge that is especially fruitful for the health care is given (i.e., recognition of statistical fluctuation, system view, five focusing steps). With regards to the "the core"; First they provide an intuitive suggestion on what the performance measures equate to in the health care enterprise both in for-profit and not for profit setting;

For-profit:

Goal statement; "*In a for-profit enterprise, one assumes that the goal of an organization is to make money both now and in the future.*"

- Throughput; "*all the money flowing into the practice through the variety of services provided to patients minus the totally variable costs.*"
- Operational Expenses; "*all the money going out of the practice such as wages, salaries, utility expenses, and interest payments.*"
- Inventory; "*all the money invested in things the system intends to sell. Inventory includes any physical inventories such as raw material, work in process, unsold finished products, and includes tools, building, and equipment. (Conceptually, patients waiting for treatment can be viewed as raw material or work-in-progress inventories.)*"

Non-profit:

More interestingly the intuitive translation from this to the non-profit enterprises;

Goal statement; "For a health system, the goal could be defined as "to provide quality health care to a particular population now and in the future"Throughput; "units of health generated", and following from this measure Tomolo et al. views the following as conditions for how "effectively" the organization utilizes the money resource it got:

- First; "expenditure on current operations" measured by; "how much T was generated per dollar spent in operating expense (T/$OE)"

[6] 48 citations registered at Research Gate; https://www.researchgate.net/publication/10965083_Applying_the_Theory_of_Constraints_in_Health_Care_Part_1-The_Philosophy/references

- Second “investment (or saving) in future operations” measured by “how much T was generated per dollar invested in the system (T/$I)”

4.4.4.2 *Schaefers et al. (2007)*

Schaefers et al. wrote an article aimed for the promotion of the public health care sector’s transitioning into TOC. Like Tomolo, Burton-Houle, & Aron (2002) it gives an account for FFS and some principles of TOC. With regards to the core Schaefers et al. give a rigid, however, a complicated way of applying TOC based on the conventional (however, controversial) health measures.

Goal statement; “*to make more health today as well as in the future*” where this “health” is proposed to be any one of the conventional general health measures the hospital sees to be reasonable (e.g., DALY, QALY DALE, DLE HALE, etc.)

- Throughput; “the number of actual accumulated goal units per unit of time.”

To underpin this goal-statement, Schaefers et al. suggest two measurables; quality and effectiveness. Firstly, calculating throughput value which is defined as “legitimate goal unit,” which is the increasement of expected lifetime expectation and life quality. Secondly, calculating the quotient of actual goal units achieved, and legitimately expected goal units achieved.

- Inventory; “how much legitimate goal units in the hospital yet to be realized.”
- Operating Expenses is unchanged from the traditional implementation of TOC in manufacturing organization, i.e.; “all the money the organization spends in order to transform inventory into throughput.”

This article might be considered a precursor and motivating for as this is suggesting to do what this dissertation is going to perform in the analysis (CHAPTER 5 and 6)

4.4.4.3 *Gupta, Bridgman & Kaur Sahi (2015)*

Gupta, Bridgman & Kaur Sahi (2015) wrote an article towards the smaller private non-profit healthcare providers. More specifically for the Mental Health Services and how they could improve their marked orientation. In great contrast to Schaefers et al. it is taken consideration for how the workers will of the health institution receives the proposed system. And addresses elements such as reassurance and fear amongst the upper management. Which seems like a

necessity for implementing such a big change in the organizations' fundamental structure. This is a good trend. A good point for letting the administration define the component of the goal themselves instead of mandating controversial measures such as DALY etc.

The article operates on the following definitions;

Goal statement; "provide therapeutic rehabilitation groups and outpatient groups therapy services to its members."

- Throughput; "money received from grants, donations, and importantly, reimbursements from third-party payers for various clinical services."
- Operational Expenses; "clinicians and staff salaries, rent, utility expenses, bills, office supplies, art supplies, and food."
- Inventory; "this includes the value of the building, computers, furniture, other sellable assets, and work-in-process."

4.4.4.4 *Sadat et al. (2013)*

Sadat et al. (2013) wrote an article called "*Theory of Constraints for publicly funded health systems*." The article provides a transformation of TOC to publicly funded health (i.e., non-profit) systems where they use the approach of the stock-and-flow diagram from system dynamics (SD) to carry out the transformation from traditional manufacturing setting to the non-profit setting. Sadat et al.'s article is, in a way, an amalgamation of the system dynamics and Schaefers et al. proposed reasoning (i.e., intuitive performance measure transformation). The result of this work is a conceptualization and visualization of QALY-accounting (as opposed to the traditional throughput accounting) situated in a stock-and-flow diagram.

From the four presented articles in the category "Global / Core," this is the article that in the greatest degree function as a precursor of this present dissertation. It is the one that has gone in the greatest degree of and is certainly the pinnacle of the four reviewed articles within this category.

Discussion about the resulting framework

Seen from the overall perspective, the selection of transformative strategy (i.e., using stock-flow interpretation from SD) has put vast constraints on the transformation. Using stock-flow conceptualization may not in itself be led to these problems.

The transformed framework's accessibility is, to a certain degree, limited, as this is a very technical framework. However, this could be a worthy trade-off if it were not for the further identified problems. It seems that the concern of making the transformation in an SD-representation made the result suffer a lack of some of the important aspects of the performance measures. The transformation for public hospital lacks an equivalent for either operational expenses or inventory (it's unclear from the article which one of them that is omitted).

However, using the chosen SD framework for the transformation might lead to a firm and coherent way of carrying out the transformation if the mentioned shortcomings are avoidable within this framework. The resulting framework does not seem to take into account that the two sets of performance measures represent the same just in from two different angles. Hence their conversion includes an attempted transformation of all the six performance measures, which seems to result in the loss of a counterpart to the traditional parameter — a transformed equivalent to either operational expenses or inventory.

The transformation leads them to superpose a goal one-dimensional goal like QALY or DALY. This led to the coherency between the goal, and the performance measures get weakened. This necessity of having an arbitrary health economic measurement as overarching goal forces the hospital upon measures that one might not agree to, as these measures are often controversial.

4.4.5 Conclusion of Review

The number of articles written on the transformation of the value structure, which is necessary to get a full-worthy transformation of TOC, is scarce. Tomolo, Burton-Houle, & Aron (2002), Schaefers et al. (2007) and Gupta, Bridgman & Kaur Sahi (2015) was mostly tentative in their change of the value-structure. Sadat et al. (2013) went further than any other to make a detailed and explanatory work that more concretely than the showed how TOC's values structure should be adjusted for the expanded utility in the sphere of the publicly funded hospital sector. Although it was the best transformation yet, this transformation had weaknesses that are both hard to disentangle (lacking coherency in transformation of the performance measures lead to missing performance measure for the publicly funded healthcare setting) and circumvent (the necessity to have a one-dimensional goal which is a severe constraint to an enterprise that can not necessarily operate on profit-maximization). These two obstacles will, in the greatest degree, possible be neutralized in the further work of this dissertation (CHAPTER 5).

Summary of Chapter

This chapter is the logical conclusion of what goes under the "assimilation"-process of the methodological ACAP-model presented in SUBCHAPTER 4.1. This chapter aimed to present the underlying theory that is subject to transformation in the two following chapters, which will entail the next step of the ACAP-model.

The landscape in which TOC exists, how this universe manifests itself in the sector at hand, the main elements of TOC, and critique of its usage in the sector at hand. The most important observation of this chapter is the notable and inevitable paradoxes that lie within most past implementations of TOC in hospitals. The work of the next chapter will attempt to provide a remedy for these inconsistencies.

The main takeaway from subchapters;

Several elements have been brought throughout the subchapters of this chapter. Following is a list of what is wanted for the reader to have as the main takeaways from each of the subchapters.

- SUBCHAPTER 4.1; The landscape of OM, three major OM-theories; Lean Management, Six Sigma, and Theory of Constraints.

- SUBCHAPTER 4.2; Transforming OM-theory for the public hospital sector might be conceptualized as a challenge with three main barriers to overcome, and the last barrier is the least accomplished.

- SUBCHAPTER 4.3; Main principles and tools of TOC. The profound and distinct idiosyncrasy of its value structure; *three and only three variables are needed to define what constitutes an improvement.*

- SUBCHAPTER 4.4; Few articles about TOC hospital implementation revolves around going through the last barrier OM-transformation in (presented in SUBCHAPTER 4.2). Which inevitably causes paradoxes within most past implementations of TOC in hospitals.

Chapter 5: Transformation of TOC

This chapter aims to fulfill the goal of constructing a general-purpose conceptualization of Theory of Constraints (TOC) that can be applied for any value-based or non-profit organization, i.e., stepping through the last barrier presented in SUBCHAPTER 4.2. The framework presented in this chapter will be demonstrated at its use in the subsequent chapter and be implemented into the concrete application of a public hospital's values (CHAPTER 6). This aim is going to be met by generating a general view of the theory that allows for a firm reconstruction into any context-specific circumstance.

The experienced reader from TOC-community might be wondering why so little of the overall methodology is brought up in this chapter. This is due to the purpose of this dissertation to firmly transform only what lies at the core of TOC and not the many tools it consists of. Albeit, the assumption here is that the tools such as those found in the Thinking Processes, the focusing process and tools and principles alike will not be affected by the transformation of this core and will still remain as good tools despite performing the transformation. This assumption gets partially confirmed in (SECTION 6.3.1 - 4). By doing this, this work will attempt to transcend and tentatively replace the previously done attempts on transforming TOC by avoiding the flaws identified in SECTION 4.4.4.

Strategy for Transformation

This section will describe the roadmap of the transformation performed in this chapter.

When ascending and descending the ladder of abstraction (presented in SUBCHAPTER 3.2) while doing this, we have to make sure that the cohesion of the theory is maintained and stays the same. The individual *terms* and *their conjunction* need to travel the same path such that this coherence remains. Such that the underlying mechanics hopefully not will be affected negatively. This was be made sure of using an analogy, which serves as an anchor in which serves as a model that convey the terms in a meaningful way.

In the previous section, there was given an account of what parts of the theory that is going to be transformed. The following figure, FIGURE 5.2, depicts how the transformation takes place

in accordance with the abstraction ladder. First, by taking the core of the traditional implementation to make it abstract. And second by implementing it into a new situation of the theory.

Roadmap for the Transformation

This subsection will present the strategy for the transformation and the steps within it. Following is the steps in the roadmap of the transformation;

1) Defining the scope of what is going to be transformed (i.e., the core), SUBCHAPTER 5.1
2) Analyzing the object of transformation; its composition and structure (SECTION 5.2.1).
3) Abstract the object of transformation from its situated traditional interpretation (SUBCHAPTER 5.2).
4) Use analogy to situate the abstract interpretation firmly (SUBCHAPTER 5.3).
5) Situate the object of transformation into the new application (in CHAPTER 6).

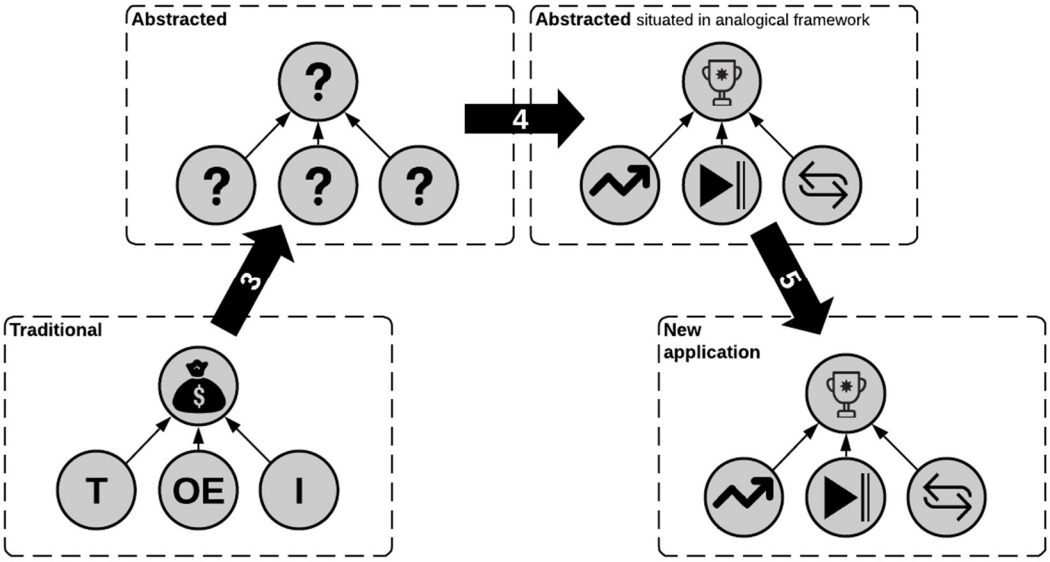


Figure 5.1 – The roadmap for the transformation of "the core." Step 3; Abstracting the core from its traditional terms. Step 4; fixing the abstract interpretation into an analogical framework. Step 5; concretizing the core into the new application at hand.

5.1 Scope of Transformation

The aim of this subsection to set the boundaries on the scope of transformation. As already revealed in the introduction, the transformation that has been done in this project is to what is perceived as the core of TOC. The following sections contain two separate arguments towards why the scope of the transformation should land where it ended, aside from the paradoxes mentioned in the critique of literature given in SUBCHAPTER 4.4.

5.1.1 The most fundamental constituent element of TOC

To get a coherent transformation, it is essential to get all the separate pieces including, but also their conjunction. So, what is the most fundamental constituent elements of the theory? What should be chosen to be the most basic presuppositions that everything else in the theory of constraints builds upon (i.e., the axiom)?

In the original literature, where the theory was first articulated (Goldratt, 1984), the core of theory was presented in a narrative format. Thus the core of TOC was not as concisely presented

as it otherwise could have been done in a regular. However, Goldratt (1999) boils down what we can call the core of TOC:

> *"The first step is to recognize that every system was built for a purpose. We didn't create our organizations just for the sake of their existence. Thus, every action taken by any organ –any part of the organization– should be judged by its impact of the overall purpose. This immediately implies that, before we can deal with the improvement of any section of a system, we must first define the system's global goal; and the measurements that will enable us to judge the impact of any subsystem and any local decision, on this global goal." (Goldratt, 1999, p. 5)*

We here get described quite clearly that it's the goal *itself* and the belonging *performance measures* that have to be figured out before one even can phantomize which initiatives that will lead to betterment. One cannot say what's better or not without having a goal, and the measurements are the first derivation of that. Hence, this is, therefore, put like that is at the core in order to know if what is done is worthwhile as an improvement. Also, it's saying that before one can see even phantom what constitutes an "*improvement*," one must have a goal. And that's what the measurements are; to decompose the goal into smaller conceivable elements which are easier to operate on; they serve as an extension or proxy for the goal itself. Thus, the assumption from this with regards to the transformative work is that this is what's regarded as the most fundamental axioms of the theory. Hence every other part of the theory is subordinate to this and serves as measures to underpin this axiom.

The original literature gives an extensive account for both the goal the two sets performance measures that is situated in the traditional production manufacturers situation (SECTION 4.1 - 4.3). The claim that the definition of the goal and its parameters is the core of is what is at the most fundamental core is also backed up by multiple articles on the topic (Naor et al., 2013, p. 544).

Once elements of a theory are put as axioms, the rest of the elements get perceived as a means of advancing towards whatever is set at the pinnacle. In FIGURE 5.1, there is given a visual representation of hierarchical relation this implies.

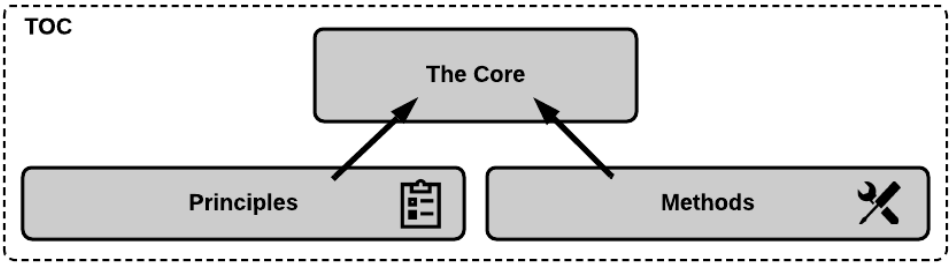


Figure 5.2 – Axiom hierarchy of TOC, the placement of "the core" as the axiom, and its relation to the other elements of TOC. Hence, explicates the other elements as *tools* to underpin the core and not the other way around.

5.1.2 Remedy towards Barrier for Non-profit Value-Structure

This second argument concerns the displayed conceptualization of the barriers of getting OM-methodologies to fit in the public hospital setting, where the last one is concerned with the value structure being the main differentiating factor. The other barriers have been more dismantled in a much greater degree through most of the literature already. better get a congruence of NPO, this is the last step of the barrier-model, and this is the part that has been worked least on by looking at the reviewed articles.

Thus, this basic argument here is that the transformation of the core is what is needed to attain the needed shift in value structure so that the theory can accommodate a non-profit organization.

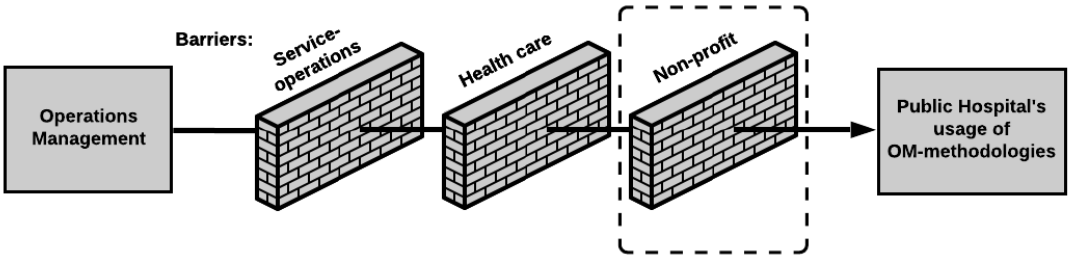


Figure 5.3 – Performing the transformation of the value structure of the theory would open the possibility to allow for a non-profit value-structure of the organization.

5.2 Transforming the Core of TOC

The transformation will be done term by term while the coherency is tested at the end through the analogy. Having an articulated goal is a necessity to be conscious about what measures that will serve the operations in a good or a wrong way. The performance measures will serve the purpose to make it possible to track and make an account the improvement of different improvement initiatives.

This abstraction is going to be performed in two steps;

1) Verbal abstraction on the goal definition and performance measures in order to disentangle the terms from the economic and manufacturing fabric they are made off of.
2) Then; Conserving the interplay among the goal and performance measures through the use of physical analogy.

5.2.1 Transforming the Global Goal

This section is divided into the subsections directed to analyze and abstract in order to perform the transformation of the global goal and its performance measures. This process is akin to a small-scale application of the two steps (assimilation and transformation) of the overall method presented in (SUBCHAPTER 4.1).

There are three alternatives to choose from:

1) Verbal content (SUBSECTION 5.2.1.2)
2) Abstraction of mechanics of the goal (SUBSECTION 5.2.1.3)
3) Or, goal by the desired move in performance measures (SUBSECTION 5.2.1.4)

5.2.1.1 ***Analyzing the Goal Statement***

Firstly, it is important to recognize why having an explicitly stated overarching goal at all is such a crucial prerequisite in order to start implementing TOC into any kind of organization in the first place. The system's goal is what explicating what should be regarded as an improvement, without a goal it is impossible to know if the impact of a certain measure leads to an improvement or not (Goldratt, 1999, p. 5). The goal's main function is to establish what the organization is aiming towards and to use as a compass to base all the actions upon. Thus,

one cannot say if the impact of a measure led to improvement without considering the goal. Secondly, having a goal is a prerequisite for applying TOC by looking at the very definitions . By looking at the definition of *constraint* according to the founder E. Goldratt himself, one can see that constraints are dependent on the very existence of having a goal;

> *"A system's constraint is nothing more than what we all feel to be expressed by these words: anything that limits a system from achieving higher performance versus its goal." (Goldratt, 1999, p. 5)*

5.2.1.2 *Abstracting the Verbally Explicit Part of the Goal*

In the abstraction, there are some particularities that wanted to be maintained in the purpose of getting a general goal-statement, and there is some that are unwanted. The aforementioned goal is containing the element of shareholder (the owner of the system), monetary value and this is what's not applicable for all types of organizations; public/governmental/non-profit organizations don't have shareholders, and they do not serve the return any profit towards something that can resemble an owner. A public organization's reason to exist is to serve the sole purpose of why it was founded.

Following elements are contained in the traditional goal statement:

Table 5.1 – Verbal abstraction of the goal.

Verbal elements of statement	Transformation	Result
Value (monetary)	→	Increments of goal attained (non-monetary or monetary)
Shareholder	→	Stakeholder

This statement is a bit weak as the stakeholders often have a loose connection to the organization (e.g., non-profits) and thus will not oversee the improvement in the same way as a shareholder, the goodness of operations is hidden and might hard to evaluate of outside stakeholders. So, this abstraction could be taken to a further, then this mere verbal abstraction, level so that the result will 1) encompass a bigger roam of possible goals 2) and abstract away this component of oversight property that really makes sense in the traditional for-profit interpretation.

Following figure show this transformation in the context the abstraction ladder presented in (SUBCHAPTER 4.2):

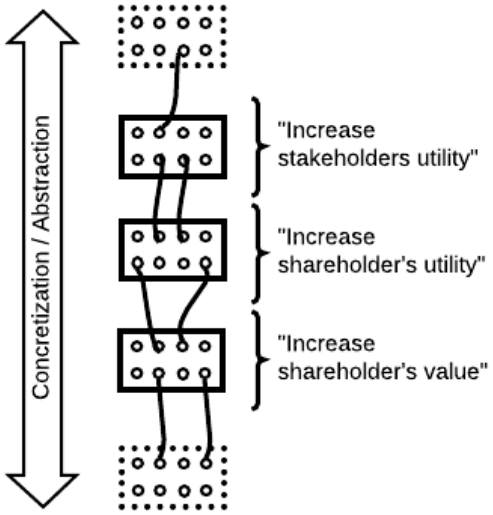


Figure 5.4 – Abstraction of the goal in the abstraction ladder. Two strings between these two verbal levels to illustrate the goal element and limit element as particularities that is kept.

5.2.1.3 *Abstracting the Implicit Parts of the Goal statement*

The goal as it is presented in the context of a pure traditional manufacturing organization as defined to be "*increasing shareholders value*" (SECTION 4.3.4). By analyzing the goal from TOC fitting the pure manufacturing company, this goal has the following mechanics that may be taken into consideration of maintaining through the transformation;

- It considers the total output of the whole organization, it does not mandate the optimizations of a single function of the system, but the totality of the system itself
- It is able to orient the whole organization to distinguish improvement from stagnation
- It can never be fully achieved, encourages perpetual improvement

When analyzing the traditional TOC goal of profit maximization, we have several contextual, circumstantial, contingent frame conditions that limit what the achievable potential, e.g., one cannot process more resources than what the specific resource marked has to offer of goods, budget limitations, one cannot sell more goods than what the marked requests, the price of the

finished products limits the demand of that product, the production cost per unit will impact how profitable the selling of the product is etc. All these are examples of such inherent constraints brought by the circumstantial particularities. The given examples are general, and there is sure to be more situation specific frame conditions from implementation to implementation. All these conditions are putting boundaries along different dimensions on what is the "true potential" of the situation with regard to profit maximization.

Analyzing the traditional goal in a more profound way, one could say the goals are also implicating the demand of the business to take the maximum of a potential. Where the marked is what the manufacturer needs to orient towards in order to maximize the profit.

The nature behind the achievement of having a goal is in a broad sense to realize what is from the potential and turn most out of it into the actual, i.e., maximizing actual from potential. This maximal potential perhaps might be only achievable in theory.

Considering what is stated in the last couple of paragraphs, one could argue that the goal stated as "*maximizing the profit*" is actuality is not telling the full story. The contention in this work is that, at least when abstracted, the goal represents the aim of turning the circumstantial actual as close as possible to its true potential. The figure is an attempt on a depiction of the relationship between actual and unmet potential.

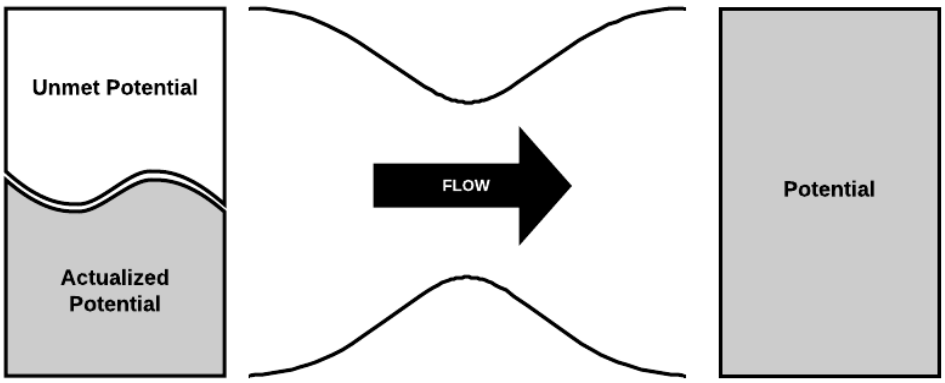


Figure 5.5 – Ill. of the relation between unmet potential, actual, and full potential. Seen from this perspective, the act of reducing unmet potential is a form of flow (i.e., what is known to be throughput).

5.2.1.4 *Goal by the desired move in performance measures*

This alternative is based on what is stated in the original literature "The Goal" where the following is stated;

> *"Okay," I answer, "so I can say the goal is to increase net profit, while simultaneously increasing both ROI and cash flow, and that's the equivalent of saying the goal is to make money." "Exactly," he says. (Goldratt, 1984, p. 66)*

Following this quote allows for making a post hoc construction of the goal; first make the transformation of the performance measures, and afterward put the demand corresponding movement of the performance measures as the goal itself.

The goal statement out of the reasoning of the alternative be the following; increase the flow, while simultaneously reduce viscosity and absorption. (see SUBCHAPTER 5.3)

5.2.1.5 *Resulting Goal statements*

Following are the three alternatives for abstracted goals.

Table 5.2 – Result from abstracting the goal statement in the three different alternatives

Traditional	Conventional description from TOC literature	Verbally Abstracted Version	Abstracted
Goal	"increasing shareholders value" (Rahman, 1998)	"Increase stakeholder's utility", "reducing unmet potential in the system" or, "increase the flow, while simultaneously reduce viscosity and absorption"	***Goal***

5.2.2 Transformation of the Global Performance Measures

As explained in theory, SECTION 4.3.4 includes all the necessary elements that are needed to know if the organization has moved closer or further from the goal. Both of them works independently and at the same times tells everything that is needed. The following subsection will go through the similarities so that the abstraction only needs to concern one of them.

5.2.2.1 *Exploit the Isomorphic relation between the two sets of Global Performance Measures*

The two sets of global performance measures, FGPM and OGPM, as explained (in SECTION 4.3.5) represents everything one needs to know to decide if the traditional manufacturing company is moving towards or away from the overarching goal. The only difference being the perspectives they are situated in; financial and operational, respectively. This subsection is going to try to establish the commonality across the two sets so that it is only necessary to abstract the commonalities and not both of them in the next turn.

By the claim that the two different sets hold all the information needed, we should be able to identify commonality across those two sets of measures that bear the same fundamental representations. If this claim can be redeemed, that means there is only one set of parameters that needs to be considered in the transformation.

Throughput, which is the measure of money generated through sales has trivially directly parallel with the measure of Cash Flow the only difference being that cash flow representing a rate as cash flow is an accumulation throughout the actual period. Next, Net Profit, which is the difference between Revenue and Expenses, given that throughput is encapsulated in the previous this measure this only adds the Expense-portion. Thus the only new thing that net profit brings in that cash flow hasn't is the expense-part, and this directly covered by the Operational Expenses-measure in the OGPM. Finally, ROI, which is the ratio of Revenue and Inventory, logically only introduce inventory which has is the last measure of the OGPM .

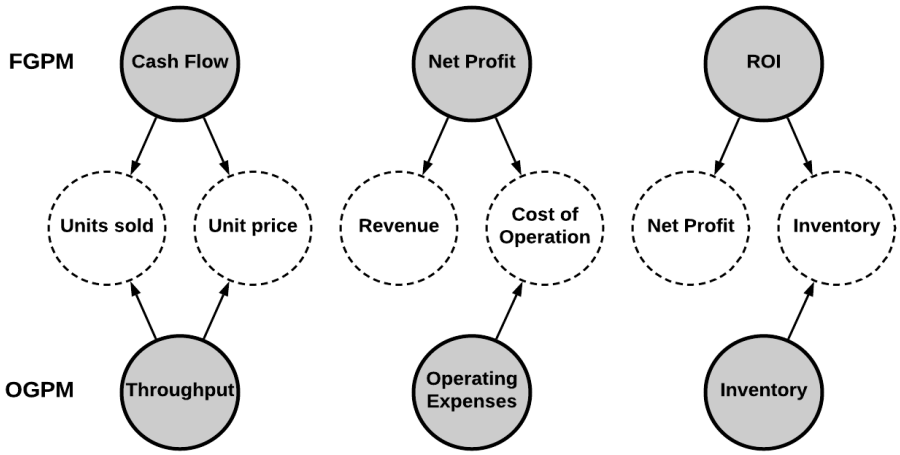


Figure 5.6 – Mapping the commonalities between the two sets of GPM's to underpin the claim of isomorphic relation of the two sets, so that the scope of transformation can be limited to one of them.

Having done this demonstration of the isomorphic property of the two GPM-sets the further transformation will only consider the of OGPM (throughput, operational expenses, and inventory) because of this set is they are slightly less complicated and thus a bit more intuitive to work with. This because, as we see from FIGURE 5.6; FGPM and OGPM are the same only FGPM as an extra "layer" on it, so the commonalities of the two sets are all included in in the FGPM.

5.2.2.2 *Analyzing the performance measures*

This abstraction of the performance measure is using the definition found in the seminal review-article written by S. Rahman, where he reviewed the general contents of the philosophy and applications of TOC (Rahman, 1998). TABLE 5.3 displays the summarized definitions;

Table 5.3 – List of definitions of the OGPM known from the TOC-literature situated in the profit-maximizing manufacturing industry. The outset for abstraction in this transformation.

Performance measure	Conventional description from TOC-literature
Throughput	"The rate at which the system generates money through sales" (Rahman, 1998)
Operational Expenses	"All the money the system spends in turning inventory into throughput." (Rahman, 1998)
Inventory	"All the money invested in things the system intends to sell." (Rahman, 1998)

5.2.2.3 *Abstracting the Performance Measures*

In the abstraction of the parameters the definition found in the seminal review article written by S. Rahman where he review the general contents of the philosophy and applications of TOC (Rahman, 1998). These definitions listed TABLE 5.3 is going to be the outset for this abstraction

Throughput

Looking at the definition presented in TABLE 5.3; "The rate at which the system generates money through sales." (Rahman, 1998)

Here there are there two particularities that are in the way from being applicable for the general organization. Like the traditional goal-definition, we have monetary elements that do not fit to the non-profit context.

1) 'generate *money*':
   Must be seen in the context of the traditional overall goal "increasing shareholder's value," since this "value" got needs translated into "goal units"/"increments of goal attainment." Thus, consistency requires that "generate money" gets treated in the same way. I.e., what is to be consistent here is "generating money" should be "generating goal-units."
2) '… through <u>*sales*</u>':
   The last part is a clause to ensure that "throughput" gets understood to entail what is sold to the customer and excludes inventory from that. In a way, this is just

explicating/reinforcing “generating money” and is thereby not in actuality providing any new information if the words in the first part is closely examined.

Thus, by abstracting these two elements, we can put the new throughput-statements as follow:

“The rate at which the system generates goal-units.”

To lessen the confusion between the traditional version and this new abstracted set of parameters, it could be wise to rename the parameters. An alternative name on that will distinguish the traditional context could thus be “Flow” (this in the context of the mechanics provided in the usedt analogy, see SUBCHAPTER 5.3).

Operational Expenses

“All the money the system spends in turning inventory into throughput.” (Rahman, 1998)

1) ‘All the system *money spends* …’
   This part refers to the amount of resources.
2) ‘… turning *inventory* into throughput.’
   And this refers to what the system demands to generate new goal-units from the resources it has.

“The effort the systems exert in order to translate resources into goal-units.” To give this parameter a qualitative abstraction to keep this apart from the traditional definition. One can think that this is the organizations' inner resistance to generate goal-units. Thus a descriptive name on this could be “Viscosity” (this again, in the context of the mechanics provided in the usedt analogy, see SUBCHAPTER 5.3).

Inventory

“All the money invested in things the system intends to sell.” (Rahman, 1998)

1) ‘the *money invested* in things in the system …’
   These ‘money’ is the invested resources that are locked (or temporarily bounded) within the organization. Proper abstraction could thus be ‘the resources locked within the system.’
2) ‘… intends to *sell*.’

This is a clause parallel to that in the second element of the previous parameter. Albeit, here it's not implied in the previous word of the statement. It underpins that what's matter is what goes out to the customer. In contrast to the previous parameter, this is not a contingency that can be deduced from the first part of the statement. So, to keep this clause remain in the abstract transformation, it can be abstracted in the same fashion as the previous parameter as "unit."

From this the abstracted inventory definition could be;

"All the resources vested in the system that is intended for conversion to goal-units." Here a qualitative abstracted name on is "Absorption" (this again, in the context of the mechanics provided in the used analogy, see SUBCHAPTER 5.3).

5.2.3 Result from the Abstractions of the Value Structure

Following is a table summarizing the abstraction performed in the two previous steps (SUBSECTION 5.2.1 and 5.2.2).

Table 5.4 – Summarization of the abstracted goal and performance measures in this transformation. See SUBCHAPTER 5.3 for the explanation of the particular naming of terms.

Element + Conventional description from TOC-literature	**Abstraction**	**Resulting element** + Abstracted version of conventional description
Goal "Increasing shareholders value" (Rahman, 1998)	→	**Goal** "Increase stakeholder's utility", "reducing unmet potential in the system" or "increase Flow, while reducing Viscosity and Absorption"
Throughput "The rate at which the system generates money through sales" (Rahman, 1998)	→	**Flow** "The rate at which the system is conveying fulfillment of the goal"
Operational Expenses "All the money the system spends in turning inventory into throughput." (Rahman, 1998)	→	**Viscosity** "How much resources the organization must use to push forward flow"
Inventory "All the money invested in things the system intends to sell." (Rahman, 1998)	→	**Absorption** "All resources and potential goal-units vested in the organization" / "unrealized potential goal units accrued in the system"

5.3 Analogy used in Transformation

As has been seen in the previous sections, the wording in the abstracted terms has got a physical character to them. The reason for this is so that they fit the analogy used in this transformation. In this transformation, there was used an analogy that was borrowed and expanded from the load-oriented manufacturing control (LOMC) presented briefly in SUBCHAPTER 4.1.4. Reverting back to the load-oriented manufacturing control mentioned in as they had a very useful physical analogy to the concept of constraint. This gave inspiration to this work as this is using the same concept, just taking it to the next level. This borrowed analogy was extended in the use of this dissertation compared to how it was used in the past.

The use of analogy in this dissertations transformation effectively serves two purposes. The first purpose is that it holds the overall coherency of what gets transformed. The second purpose, it contributes to give its constituent elements meaningful terms in the abstract roam so that it can easier to understand.

5.3.1.1 *Funnel Model from LOMC*

G. W. Plossl used the imagery displayed in FIGURE 5.7 to describe the importance of controlling and monitoring both the input and output of working orders (Plossl, 1983, 1985; Wiendahl, 1995, p. 33). The model, as we see, eloquently describes the relationship between orders, lead time, capacity, and output rate. The analogy conveys the important elements from the manufacturing setting and derives it into the physical model of a funnel with input and output valve.

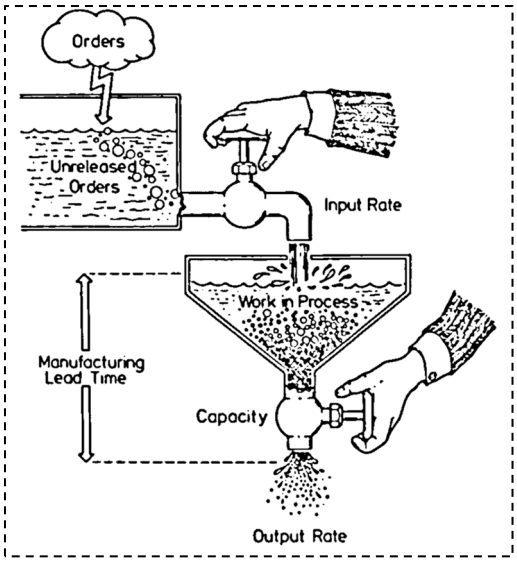


Figure 5.7 – Imagery found in the Load-Oriented Manufacturing Control containing useful pictorial qualities in portraying the constraint as a liquid passing through a funnel (Plossl, 1983, 1985; Wiendahl, 1995, p. 33).

5.3.2 Exceeding Past Conceptualization to Express Elements in this Transformation

The existing performance framework in the traditional interpretation of TOC displays the attainment of the overarching goal through three variables; throughput, operational expenses, and inventory.

Taking this conception even further (to incorporate the abstracted version of TOC):

1) Throughput → FLOW – Corresponds to the liquids' physical rate of flow through the of the opening. This is influenced mostly by the wideness of the funnel opening at the narrow end. Which intuitively would correspond to what would be called the constraints capacity in TOC terms.

2) Operational Expenses → VISCOSITY – Viscosity of the liquid, is the internal friction of the fluid flowing through the funnel. Depending on the viscosity (the internal friction) of the fluid, the fluid will be either get slow or faster through the narrow end depending on higher or lower viscosity.

3) Inventory → ABSORPTION – Depending on how much fluid inside the funnel that is waiting to flow out toward the narrow end of the funnel. Widening of the funnel increases the internal friction leaves as the fluid will experience an even higher degree of friction towards the wall of the funnel. The geometric configuration of funnel decides how much "extra" accruement stays in the funnel waiting to be released. Absorption is, thus, the amount of liquid captured in the wide portion of the funnel.

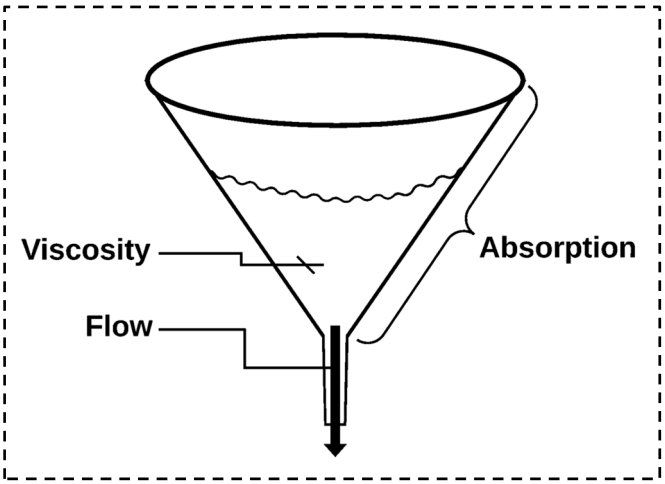


Figure 5.8 – Analogy situating the abstracted terms in a meaningfully way conveyed through the pictorial funnel, maintaining the coherency from the traditional interpretation of TOC .

5.3.2.1 *Thought experiment*

The ideal funnel would be a pipe that had no accruement of fluid. This would correspond to a factory where no inventory lies around outside of the production line. In the case of a hospital patient-flow it would correspond patients staying idle (i.e., waiting for treatment, waiting time between to tasks that aside from necessary restitution). Having a liquid with low viscosity would travel faster through the funnel as the exerted force (i.e., gravity) needs to do less work for it to travel through the funnel. Everything else equal a decrease in viscosity will require less work for the same outflux of liquid flow. Flow in the model is the rate the fluid travels through the narrow end of the funnel.

Absorption is contingent on the structural configuration of the funnel; how much excess, redundant, surplus, accruement or residue constraining, under the process of flowing out. The

wider the funnel is, the more liquid will accrue if there is higher intake than what the flow allows for. How much fluid staying in the funnel will have an impact on how much that that can flow effectively through the funnel. The absorption is dependent the physical funnel this can be caused; wideness on the funnel, angle on the . All the hindrance the system itself exerts on the flowing material. This is a consequence of the physical construction of the system (i.e.) itself, which is depending on several different factors, e.g., the difference between the wideness of funnel in the narrow and broad part, how steep the funnel

In this examples case; the relation of flow, viscosity, and funnel-load are calculatable as a relation between physical measurements and nature-defined constants. Calculation of this sort in a hospital setting might only be possible in the theory.

The resulting abstracted global performance measures:

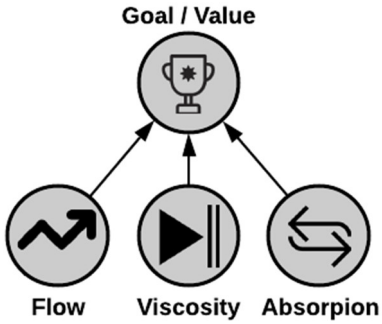


Figure 5.9 – Illustration of the abstracted version of the performance measures with the new abstracted terms for a broader reach of usage.

Chapter 6: Implementation of TOC in SUH

Now, as the last chapter properly the core of TOC, this chapter will situate the core into the values of Stavanger University Hospital (SUH). This chapter is going to suggest the implementation of the transformed framework to the public hospital sector. The implementation will be done with the administrative core values of SUH as an example. As will be further explained, the values of SUH are a good test on the transformed framework, as these values are varying in their nature from "trust" to "efficiency." By implication, this is to be sort of a decisive test of the framework.

This chapter will continue the transformation-step where the last chapter ended. The chapter is dedicated to the part of implementation if this process, i.e., last step of the 5-step strategy of transformation FIGURE 5.1 SUBSECTION "Roadmap for transformation".

Much of the content of this chapter will be preliminary suggestions and stipulative on how the transformed framework could be used to support the values of SUH. Each of the values belongs to each of its fields of discipline. Professional and firm implementation would necessitate a lot more insight than what was possible to gain during the project of this dissertation.

This implementation is represented by the last step of FIGURE 5.1, which show the overall strategy of transformation. Nested in this step is the three strategical steps for conceptual implementation in the list below.

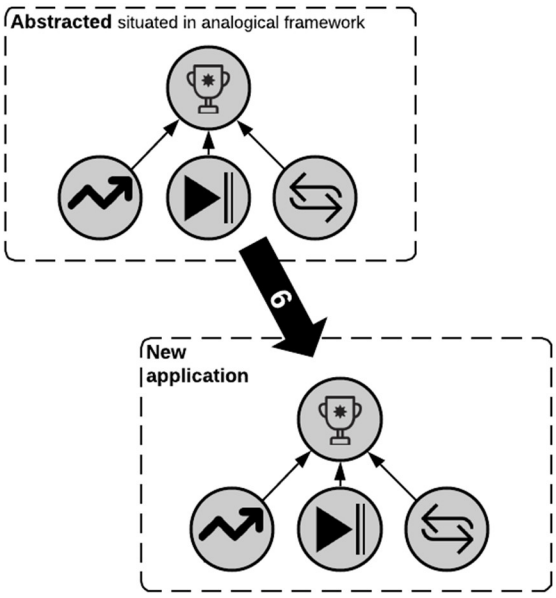


Figure 6.1 - This chapter revolves the last step, the concretizing, of the transformation strategy presented in the previous figure 5.1, CHAPTER 5.

Strategical steps for the Conceptual Implementation

This chapter is going to solely dedicated to the implementation towards of the abstracted value structure of the theory of constraints into SUH. Following are three formalized strategic steps for carrying out this transformation that is going to be carried out in the subsequent subchapters.

1) *Concretize the overarching goal for SUH* should be conceptualized to fit the transformed framework (SUBCHAPTER 6.1).

2) *Analyze the goals and values* of SUH (SUBCHAPTER 6.2).

3) *Situate the abstracted performance measures* to underpin each of the goals and values (SUBCHAPTER 6.3).

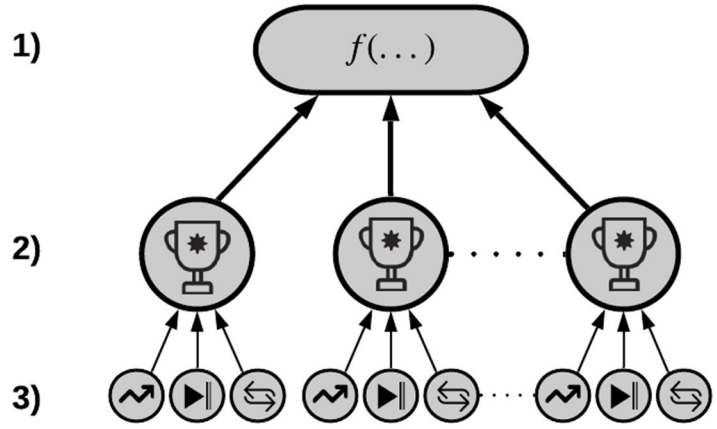


Figure 6.2 – General depiction the three suggested steps in the strategy of integrating the abstracted framework to accommodating the goals and values of an organization.

6.1 The Overarching Goal for SUH

This subchapter is going to define the overarching goal in the case of SUH based on their core values presented in their documentation for clinical leadership.

6.1.1 Setting the overarching goal for the SUH

There exists a lot of suggested ways of measuring the, e.g., DALY, QALY, etc. However, these measures would be both arbitrary and artificial for a hospital to operate upon solely. My estimation is that such goals should come from within the organization and should not be forced upon the organization. The workers of the organization are the sources of information that know what will serve best for the environment they operate within. Because if this SECTION 6.1.2 will outline a way for the abstracted framework to encompass several goals. This was done in particular to accommodate the values of SUH.

Setting an overarching goal is a tricky enterprise as there is a lot of different considerations that can be taken. However, in accordance to what was laid out in SECTION 5.2.1, we can choose among three abstract versions of the goal; the verbally abstracted, the abstraction of mechanics or goal by the desired move in performance measures. Since the further implementations are

going to concert four defined values, the last options are the one that is the most robust, as would be uniform and don't put a constraint on what the values should be.

6.1.1.1 *Possible objection from the Health Care Manager*

The experienced health care manager would probably have difficulties in agreeing with the present goal definition. One could argue that the goal instead should be "delivering health care within the given budget" or "having a safe and flourishing working environment for the healthcare professionals" and so on. However, Gupta et al. cleared up this discussion a great bit (however, for the manufacturing sector); all these other "goals" are simply necessary conditions, not the goal itself (M. C. Gupta, Sahi, & Chahal, 2013).

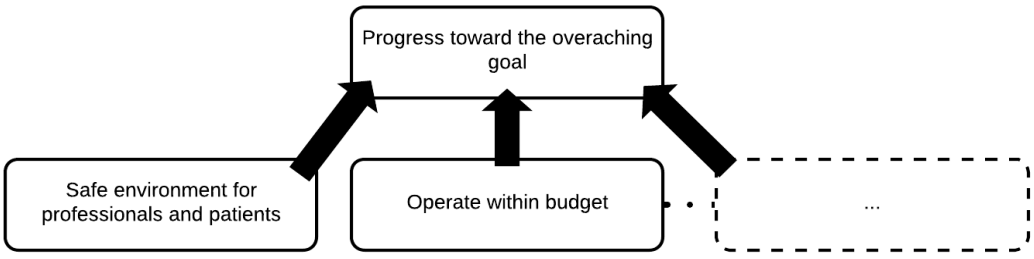


Figure 6.3 – It is important to distinguish between what is the actual goal of the hospital, and what is considered as necessary conditions.

6.1.2 Multi-Dimensional Goal

Now, as the value structure has been generalized, there are more degrees of freedom that lets room for adjustment of the value structure.

This present section will stipulate how the overarching goals could be operationalized through the framework proposed in CHAPTER 5.. This is the operating the abstract interpretation have allowed; i.e., taking several goals into account. It was not possible in the traditional interpretation as this as the terms had a very predefined/context specific definitions.

Now, as the core of the theory is disentangled from any concrete operational and financial terms, the estimation is now that there gained enough freedom that allows for scaling up on the

numbers of goal. Thus, if the resulting abstracted core is truly general the consequence of the resulting transformation of the core of the theory is that it is now –at least in principle– scalable to encompass an arbitrary number of goals.

As presented in the preceding chapters, the goal for most traditional manufacturing- and service companies is to maximize the profit. When the organization is a non-profit, it is not always so clear what should be the one overarching goal. Maybe in some cases impossible to narrow the goal down to a boiled down single expression. For this transformed framework to truly be a general framework that can be applied in any organizations, it should have the allowance for a multifaceted goal.

Non-profit organizations have the struggle to make a one-dimensional goal, like what is done in the traditional manufacturing industries. Instead, they have multifaceted aims in mind for the existence of their organizations. In making the multifaceted goal, there are two different "reasons" for having several goals at once.

1) The true main goal is not possible to be expressed. However, it is identified parameters that function as a proxy for achieving this unspecifiable overarching goal.
2) The different goals are defined as indispensable distinct qualities that

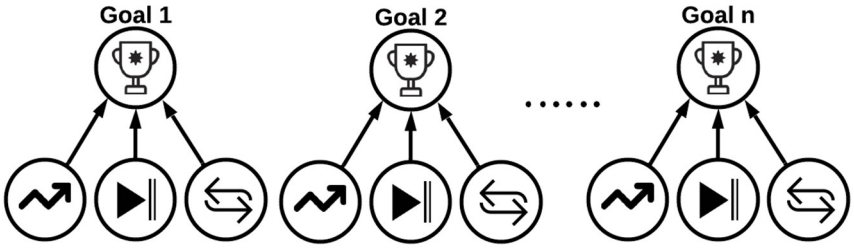


Figure 6.4 – Allowance for multidimensional goal, ass the value structure has been abstracted.

6.2 SUH's Four Core Values

Stavanger University Hospital (SUH) (presented in SECTION 2.1.3) has four core values that are defined and elaborated four core values that are the aim to underpin their clinical leadership (Olsen, Husebø, Qvindesland, & Lorentzen, 2015).

There is a lot written about the relationship between leadership and management and the hospital. The purpose here is not to go into how the leadership is going to be pursued, just stipulating how the fruits from their CL-practices can be measured in a proper way to be according to the suggested framework. Leadership and management are separated into two different. This framework provides an interface between leadership and management, as this framework provides a way to measure their values, that in the next turn will enforce fulfillment of these values if recognized and measured correctly.

This dissertation suggests the operationalizing of leadership values and intentionally juxtapose these with the traditional management goals within the same framework. The operationalization is imposed by the very implementation of the TOC-core as it necessitates the longitudinal measurements of these goals / values.

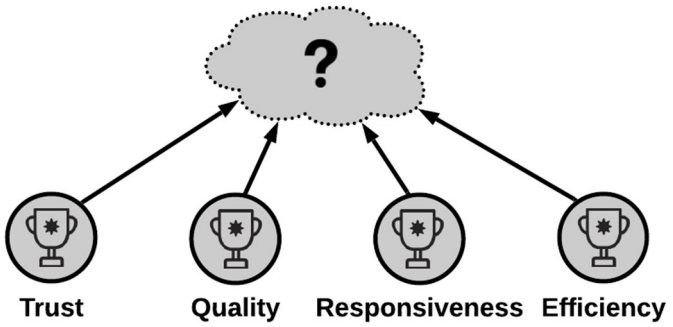


Figure 6.5 – The allowance for multidimensionality serves the purpose of allowing the organization to define components that serves as proxies for the perhaps un-definable overarching goal.

6.2.1.1 *Leadership v. Management*

Since it's here brought up leadership in the context of clinical leadership and this dissertation so far has primarily been working on management. The following is written to avoid some possible confusion and suspicion of conflating the two terms "management" and "leadership"; this subsection will clear up the terms and their relation of this work.

Leadership is typically perceived as that which is concerning and dealing with soft aspects (e.g., values, inspiration, motivation, creating vision) of an organization. On the other hand, management is typically perceived as that which is concerning and dealing with harder aspect (e.g., resource control, personnel planning) of an organization. This firm delineation is confirmed by the literature (Jonas, McCay, & Keogh, 2017; Liphadzi, Aigbavboa, & Thwala, 2017). However, leadership is viewed as a subclass of management (Liphadzi et al., 2017), so incorporating leadership-values into a framework of management must not be viewed as that unreasonable thing to do. What was the aim of the abstraction of the core of TOC was also to encompass soft aspects such as those contained in the roam of leadership. here was to make a value structure that can encompass this leadership aspect as well as the traditional management.

Instead of compartmentalizing the two aspects of leadership and management into each own division, this framework facilitates an explicit dialectical process between those two to achieve interactive integration of values and goals, management and leadership, skills and care.

6.2.2 Implementation of the transformed TOC-core to the goals defined by SUH's

As elucidated in the preceding subchapter, the values of the clinical leadership as SUH is trust, quality, responsiveness, efficiency. The meaning of these terms has been elaborately disclosed in the paper "Redefining clinical leadership for team course" (Olsen et al., 2015). These terms are shortly summarized in TABLE 6.1

Table 6.1 – The four managerial values chosen to be partial goals. The table presents a brief version of that is found in "Redefining clinical leadership for team-course development" (Olsen et al., 2015).

Value	Abbreviated descriptions of the values
Trust	The interpersonal trust which is the prerequisite for and allowing a system to have the most successful team performance internally among the healthcare providing agents. (Olsen et al., 2015)
Quality	Probability of obtaining the ideal outcome of the treatment given the present knowledge. Can be decomposed into interpersonal- and technical quality elements of performance. (Olsen et al., 2015)
Responsiveness	The relational measure of the congruency between the health care served for the patient and the expected "universally legitimate" health care from the perspective of the society. (Olsen et al., 2015)
Efficiency	The current amount of vested resources to get the ideal outcome compared to the lowest possible amount of resources vested for the same ideal outcome. (Olsen et al., 2015)

In the case of SUH's four values, it could be possible to find an operational justification for each one of them and put that operational commonality as the global goal. However, this is not a straightforward process as this will have to need extensive insight to verify the actual congruence with the hypothetical intended goal that was the underlying implicit goal of choosing the exact. The intention of this dissertation is not to evaluate the "appropriateness" of the different goals as such an undertaking in making an evaluation system would constitute the scope of its own dissertation.

6.3 *Situate the Performance Measures*

This is the last step of the application process in the overall transformation strategy. This subchapter is going to suggest how the abstracted performance measures can be interpreted for operationalization in the context of SUH's core values of leadership. This subchapter will not be going to provide the full answer on how to operationalize the values because they are each deeply embedded in their respective discipline. However, it is going to be stipulated whatever is necessary to capture through the measuring techniques in order to comply with the framework

Applying the transformed performance measures

As indicated before we quite clearly can see that these goals are complexly interrelated. However, the contention of the abstracted value structure of the theory is that the framework from the outset will –at least primarily– deal with the different goals independently.

SUBCHAPTER 5.4 presented the notion of having several goals and claimed that this could be appropriate to. This section will go through the different elements of the general framework and stipulate how their furthering can be tracked by the abstracted GPM's:

6.3.1 Trust

Trust according to how it is defined by SUH (see TABLE 6.1 for the shortened version of their definition of "trust") is fundamentally a psychometric value in its nature. This value is what typically would be represented by the outcome of good leadership as this has a soft aspect to it rather than a purely hard-skill aspect. Hence, this provides a good acid-test for the versatility to show if the transformed framework can work or not for these types of values. As presented in (SUBSECTION 5.3.3 – Result table of transformation), there are four points of interest; goal, flow, viscosity, and absorption.

6.3.1.1 *Flow of Trust*

By directly applying the derived abstraction presented in TABLE 5.4 we get the following concretizing of the flow of trust; "The rate at which SUH convey internal trust within and between the healthcare system and the healthcare provider."

Suggestions on how to measure:

- This could be measured by interviews and surveys at both hospital-level and ward-level and the healthcare providers.
- To capture if the flow is increasing or decreasing the survey should include aspects concerning how the trust has been in the past, how it is perceived at the present time and how the future trust is evaluated is considered for the surveyed parts.
- For a more comprehensive view, it could be proxied to quantitative forms of data, e.g., how many re-checks of patient journals, numbers of personal conflicts.

6.3.1.2 *Viscosity of Trust*

By directly applying the derived abstraction presented in TABLE 5.4 we get the following concretizing of viscosity; “The amount of resource SUH uses to uphold the trust within and between the healthcare system and the healthcare provider.”. This measure is wanted to be minimized (while everything else kept equal).

Suggestions on how to measure:

- Budgeted money on initiatives that are aimed toward initiatives and processes to underpin trust.
- In theory, this could be calculated by dividing the achieved increasement on the budgeted. This, however, is very theoretical; the trust might have good momentum from initiatives that go considerably back in time.

6.3.1.3 *Absorption of Trust*

By directly applying the derived abstraction presented in TABLE 5.4, we get the following concretizing of absorption; “Accruement of all potential trust that within the system that has yet to be realized.” Let say that there has been an investment on an initiative with a hypothesized yield of gained trust in the organization, but the result from the initiative have yet to play fully out in the system. In this case, the measure acts more as a way to explain improvements that not yet have manifested itself. The second portion of this parameter is the accumulated trust that has been gained throughout time. This will then have to be established as an absolute measure

Suggestion on how to measure:

- Psychometric surveys among patient and healthcare providers.
- Mapping out the processes and flow of the (i.e., like what is done in the example after this concretization) to assess where absorption is prevalent in the organization.

6.3.1.4 *Example of Conceptualization of Flow of Trust and use of the Five Focusing Steps*

To illustrate more clearly how hits work out in the hospital setting, This is an example that illustrates a possible way on how to conceptualize how the flow, viscosity, and absorption.

FIGURE 6.4 shows one way of conceptualizing the flow of trust throughout the hospital with a flowchart. Depending on the accuracy of the measuring techniques, such a model may or may not be possible to construct with. At least it would be constructive to model a hypothetical map that at least is approximately presenting the flow of the trust in the hospital. Also, what is possible is it could be a lesser or greater resolution, i.e., there could be a model displaying a few blocks that encompass more detailed. This model also assumes that the allocated budget is evenly distributed among the wards, in the hospital, which may or may not be the case. Completing an accurate model with the proposed level of detail would probably be a project in itself.

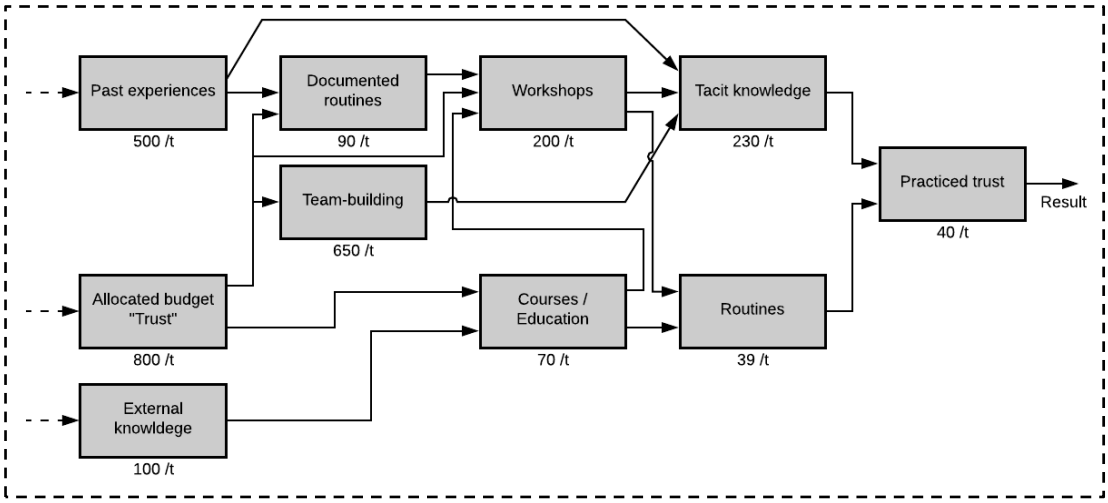


Figure 6.6 – Illustration on how to construe the flow of trust throughout the chain of processes of trust in the hospital. The presented values, order, and placement are highly speculative as it would demand an intricate analysis. Numbers represent examples of flowrate of trust per arbitrary time-unit [/t].

As depicted in FIGURE 6.4, one would imagine the conception and convection of trust will probably not following one clear path throughout the functions as a product on an assembly line in a manufacturing company would. However, this either not the case for specialized jobs performed by the typical service company where a project might shift hands back and forth through several different specialized departments before completion.

Each process can be decomposed by their intake of trust (what it gets from the other processes), how it accommodates the intake and how transferable what its producing output is for the next process in the chain. Any trust-process cannot convey more trust than what it is getting as input. Thus it would not

The meaning of the three performance measures (i.e., flow, viscosity, and absorption) in the context of this chain of processes is the following:

- ***Flow***; is the resulting capacity of all trust-processes, i.e. the outgoing branch indicated as "Result."
- ***Viscosity***; how much resources it takes to keep the processes going at the present rate. This would include primarily the directed budget towards these activities that convey trust. It would also be any other work-related that is not showing, e.g. the indirect cost of documenting an unwanted incident concerning trust.
- ***Absorption***; If the organization is using resources for processes of trust that are not flowing through the chain of processes. As we see, the first processes have a big capacity, but only parts of the full capacity of it is utilized. This is to be regarded as accruement that stays within the system and doesn't flow through the chain of trust processes. Absorption as this is piles of un-released potential in the early stages that is not fully utilized as a result of its dilution throughout the chain of processes.

From a conceptualization like the one in FIGURE 6.4, we see that it would be possible to take use of the five focusing steps as illustrated in the context of a traditional manufacturing company in SECTION 4.3.5.;

1. Identify the constraint in the system;

- The constraint in the chart is the process which is limiting the next increment of trust. This needs a closer examination to make a final judgment, to sort out what is the capacity of each process, and if this is limited by.

2. Exploit the constraint;
    - Exploitation in this regard could be to recognize that any improvements in "Team-building" will not yield an increasement of the trust. So; the if there is planned to increase the budget towards this process, it should be evaluated if the budget should be directed towards the identified constraint rather. Also, reducing the budgeted means for processes that are so high that the following processes can't make use of it, would also fall into this category.

3. Subordinate rest of the system to the constraint;
    - Making the surrounding workers around this process aware of that this limiting factor is present and orient towards the betterment of this process.

4. Elevate the constraint in the system;
    - Increase the resources on the given constraint until there is no more to gain; then the constraint is another place.

5. Repeat the process from step 1 to find overcome the next constraint in the chain.

6.3.2 Quality

In contrast to the previous value, this is a more technical term, although it entails some interpersonal aspects to it as well. In their definition, there is stated that quality is the "degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge.". According to further discussion, it appears that the interpersonal component concerns information exchange between patient and workers and among the workers. The technical component concerns how well the knowledge and judgment are according to professional knowledge.

6.3.2.1 *Flow of Quality*

By directly applying the derived abstraction presented in TABLE 5.4, we get the following concretizing of the flow of quality; “The rate at which SUH convey the quality of their hospital.”

Suggestion on how to measure:

- The interpersonal part will be measured in the same fashion as the flow of trust (SUBSECTION 6.3.1.1).
- The technical part of congruence between exerted judgment and the professional judgment could be sample tested at some randomly selected (but representative) treatment paths for different diagnosis.
- Quantitative measures, e.g., the number of complaints from patients, how many days the patient treatments take relative to the expected and standardized.

6.3.2.2 *Viscosity of Quality*

By directly applying the derived abstraction presented in TABLE 5.4, we get the following concretizing of the viscosity of quality; “The amount of resource SUH spends on the flow of quality.” Just like the viscosity of trust, this measure is wanted to be minimized (while everything else kept equal). Suggested ways of measurement will be the same for the absorption of trust (SUBSECTION 7.2.1.1).

6.3.2.3 *Absorption of Quality*

By directly applying the derived abstraction presented in TABLE 5.4, we get the following concretizing of absorption of quality; “Accruement of all potential quality that within SUH that has yet to be realized.” The suggested way of measurement will be the same for the absorption of trust (SUBSECTION 6.3.1.3).

6.3.2.4 *Example of Conceptualization of Flow of Quality*

FIGURE 6.5 is an exemplified illustration of the flow of quality, on par with FIGURE 6.4 that illustrated the flow for trust. Here we can readily see that it is possible to

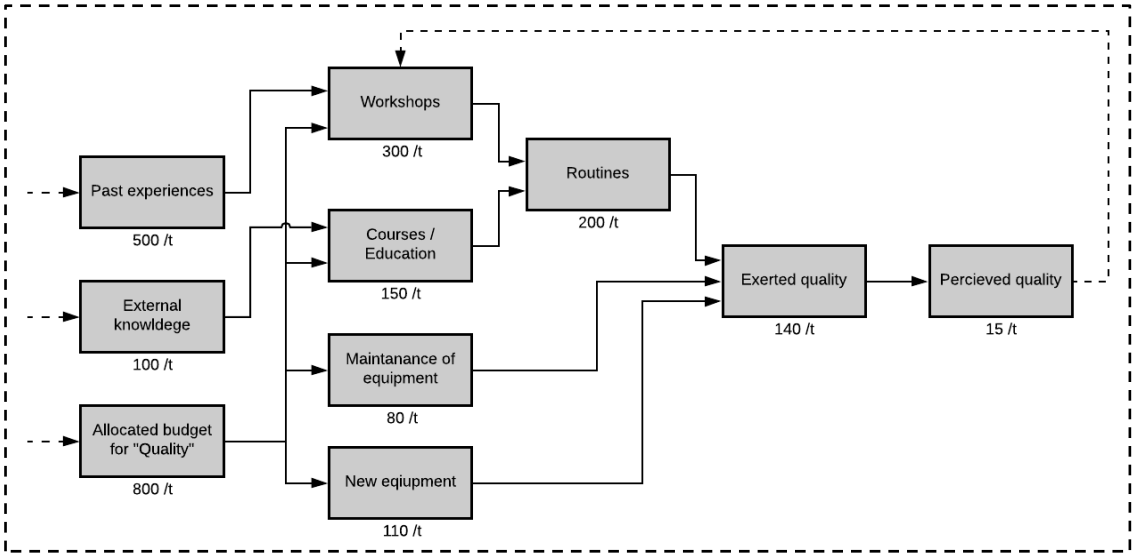


Figure 6.7 – Example on how to conceptualize the flow of quality from the budget, past experience, and external knowledge to the perceived quality.

6.3.3 Responsiveness

Responsiveness according to how it is defined by SUH (see TABLE 6.1 for a shortened version of their definition of "responsiveness") is a subjective parameter that is concerning the relational measure of the congruency between the healthcare recipient's expectation and the "universally legitimate" expectation. Expectations are at the end, fundamentally something that is subjective and personal for each patient that is going through treatment in the hospital. Hence, like the preceding parameters, this is something that is best measured through surveys. This value is composed of two portions; one concerning the societies expectations and the other concerning what SUH is providing. The first part is not something that SUH can or should try to change. What they can change, however, is how they accommodate those expectations.

6.3.3.1 *Flow of Responsiveness*

By directly applying the derived abstraction presented in TABLE 5.4 we get the following concretizing of the flow of responsiveness; "The rate at which SUH convey congruency between the health care served for the patient and the expected health care of society."

Suggestion on how to measure

Generally, it would be the same suggestions as for the flow of trust. Some additional relevant quantitative measures could serve as a proxy for the flow of responsiveness:

- Average response time.
- Patient surveys at intake, during the stay and, at the exit for comparing through a priori conceptions with the resulting experience of the patient to know if "legitimate expectations" were met or not.
- Waiting times.
- The number of the treatment courses degenerated according to protocol.

6.3.3.2 *Viscosity of Responsiveness*

By directly applying the derived abstraction presented in TABLE 5.4, we get the following concretizing of the viscosity of responsiveness; "How much-targeted resources on improving the responsiveness compared with the achieved gains in responsiveness." The suggested way of measurement will be the same for the absorption of trust (SUBSECTION 6.3.1.2).

6.3.3.3 *Absorption of Responsiveness*

By directly applying the derived abstraction presented in TABLE 5.4, we get the following concretizing of absorption of responsiveness; "Accruement of all potential responsiveness that within SUH that has yet to be realized." The suggested way of measurement will be the same for the absorption of trust (SUBSECTION 6.3.1.3).

6.3.4 Efficiency

Efficiency according to how it is defined by SUH (see TABLE 6.1 for a shortened version of their definition of "efficiency"). This is a measure of the relationship between the output (product) and the given input. Similar to the value of responsiveness, efficiency entails one part that is out beyond the control of SUH and another that they might do something about. SUH is given certain funding and budget from the government and can do little about how much they get funded. However, SUH can, to a greater degree, control is what the output they are producing with the given budgeting and funding they get. This value deviates from the other values as there is no psychometric or subjective component in the definition of this value.

6.3.4.1 *Flow of Efficiency*

By directly applying the derived abstraction presented in TABLE 5.4, we get the following concretizing of the flow of efficiency; "The rate at which SUH convey efficiency throughout the hospital." This flow can also be conceptualized as how it is suggested in for the values of

trust and quality. However, this value could take great advantage of additional conceptualizations of flow, such as what is explained in the example in SUBSECTION 6.3.4.4.

Suggestions on how to measure:

- Length of stay.
- How many of the treatments was performed within the supposed time.
- Etc.

6.3.4.2 *Viscosity of Efficiency*

By directly applying the derived abstraction presented in TABLE 5.4, we get the following concretizing of the viscosity of efficiency; "The amount of resource SUH uses to uphold the efficiency."

Suggestion on how to measure:

- How many patients waiting (i.e., excluding patients in restitution) for the next treatment in the path of treatment.
- Amount of idling time path of treatment for specific treatment with the well-defined protocol.

6.3.4.3 *Absorption of Efficiency*

By directly applying the derived abstraction presented in TABLE 5.4, we get the following concretizing of absorption of efficiency; "Accruement of all potential efficiency that within the hospital that has yet to be realized."

Suggestion on how to measure:

- Investigate the capacities; the un-utilized capacities (e.g., that is limited by constraints) is a primary mark of absorption of efficiency.

Example of different Conceptualizations

By directly applying the derived abstraction presented in TABLE 5.4, we get the following concretizing of the viscosity of efficiency; "The amount of resource SUH uses to uphold the efficiency."

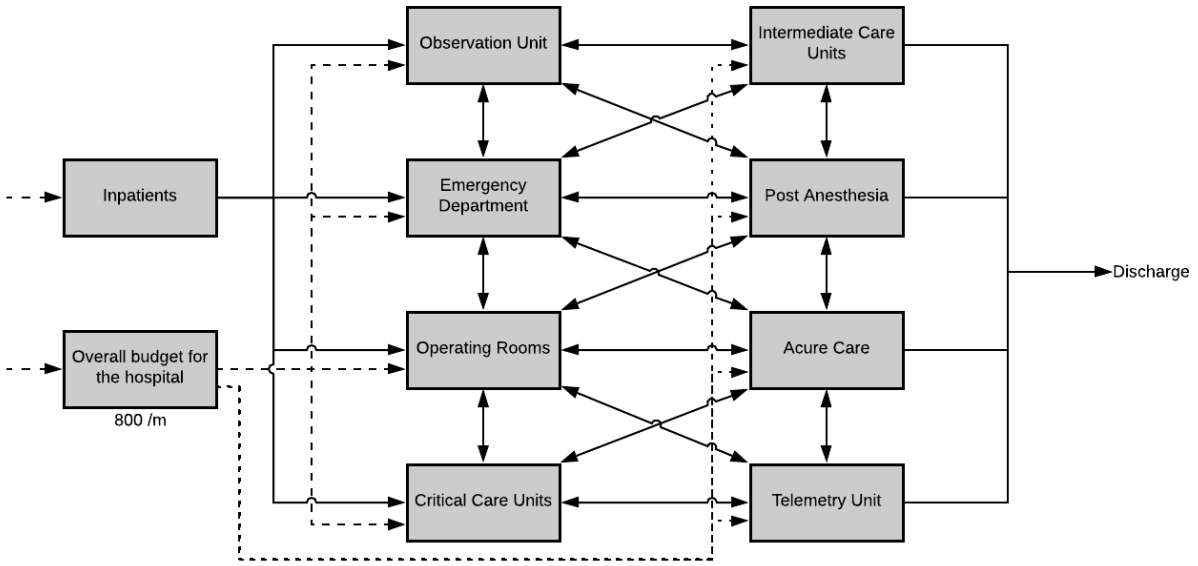


Figure 6.8 – A figure similar to the IHI's figure of hospital-wide patient-flow (Rutherford et al., 2017) could illuminate some aspects of hospital efficiency.

Figure 6.6 shows one way that of viewing the hospital to illuminate what flows that is to be most relevant as the subject for improvement. Pathways that have a high number of patients flowing through is the focus to map where most traffic exists to know where improvement is needed. This is the basic way that Rutherford et al. conceptualize the hospital in order to underpin hospital-wide patient-flow (Rutherford et al., 2017), except this model (figure 6.6) also takes into consideration the budget (which is the second part of the efficiency). Another way of illuminating efficiency is to look at different patient pathways for different conditions. Figure 6.7 illustrates this alternative.

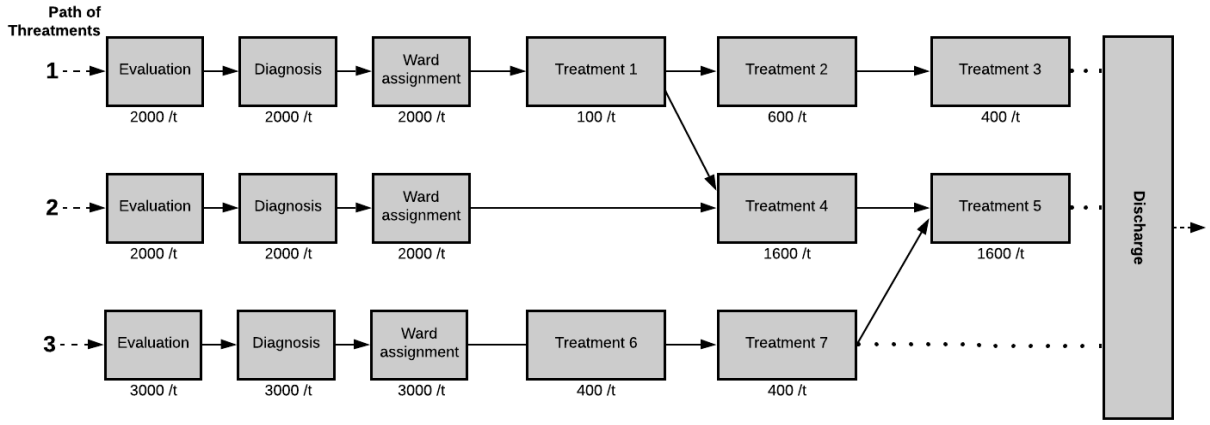


Figure 6.9 – Alternative conceptualization of patient flow showing the different pathways of treatment. Alternative conceptualizations might be instrumental for the resolvent of different types of constraints.

Example-usage of five focusing steps

The presented flow chart in the figure above provides a different conceptualization of flow in comparison to the past examples (SECTION 6.3.1-3). Thus, it might be of the interest to see how the hallmark method of TOC, the five focusing steps, functions in this way of conceptualization.

1. <u>Identify the constraint in the system;</u>

    → The constraint in the figure above is what is limiting the hospital to gain higher effectiveness. This is contingent on a plethora of factors in the system. E.g., which path of treatment that is in the highest demand. For the sake of this example, we say that the three paths of treatments are in equal demand from society. Given that, there would be an excessive amount of waiting for the first path treatment. This would mostly manifest itself through a larger amount (compared to patients in the "path of treatments 2 and 3") of patients waiting, e.g., in a hospital bed or in the hallway outside of the room providing "Treatment 1".

2. <u>Exploit the constraint;</u>

    → Exploitation here would involve an evaluation of what is causing the constraint to appear in "Treatment 1" and how much it is possible to elevate this constraint (in step 4). This is because it would be very futile to displace

health care professionals from “treatment 2 and 3” if the elevation can be performed in a short timeframe. So, for the sake of the example, we say that an investigation of the constraint in “treatment 1” reveals that it is possible to raise the capacity to 400 /t within a reasonable timeframe and to raise it further would necessitate more resources than what is economically prudent.

Thus, the exploitation after the investigation would lead to a reduction of the capacity in “treatment 2” as this is a capacity that is not possible to utilize. The capacity should if possible, be spared until the execution of step 4.

3. Subordinate rest of the system to the constraint;
    - → In short; carry out what was found in step 2. By making the surrounding workers around this process aware of that this limiting factor is present and orient towards the betterment that got stipulated in step 2. This could be initiatives such as moving excess capacity from “treatment 2” to “treatment 1”.

4. Elevate the constraint in the system;
    - → Increase the resources on the given constraint until there is no more to gain. This would happen until the treatment gets a capacity of 400 /t.

5. Repeat the process from step 1 to find overcome the next constraint in the chain.

As we see, this view provides a way that easily differentiates among the different treatments and allows for pinpointing problems in a patient proceeding throughout the full path of treatment during the stay. This differentiation provides a way to make an apples-to-apples comparison between different pathways of treatments that occur in the hospital. This example illustrates how the mere conceptualization can provide invaluable insight into how a constraint can manifest itself.

Carrying out such and conceptualization might be fruitful. Cf. the Pareto-principle 20% of the units causes 80% of the impact; the hospital could range all the different path of treatment, map

them out with details, e.g., intersections and capacities to investigate where a constraint for the flow of efficiency exist.

6.3.5 Result of Situating the Transformed Values Structure to SUH's values

The preceding subsections have gone through the four core values of SUH. This subsection provides a summarization of the proposed implementation.

Some of the parameters might seem artificial; this might be caused by a lack of expertise in those particular disciplines. However, one way to reduce this is by providing a feedback loop that allows for validation of the measures (and values for that matters) to confirm they act adequately.

As another layer on this scheme after the performance measures could be standardized KPI-values that is already implemented and operationalized in SUH. However, when dealing with those derived measures, one should be very cognizant that these only serve as proxies for the underlying measures and is in no form a definitive answer if the value har gained fulfillment or not. Incongruencies should be sought after. This could be done by periodically perform qualitative verification. If a hypothesized KPI is not confirmed to with the underlying values it is supposed to represent; it should exclude from further considerations.

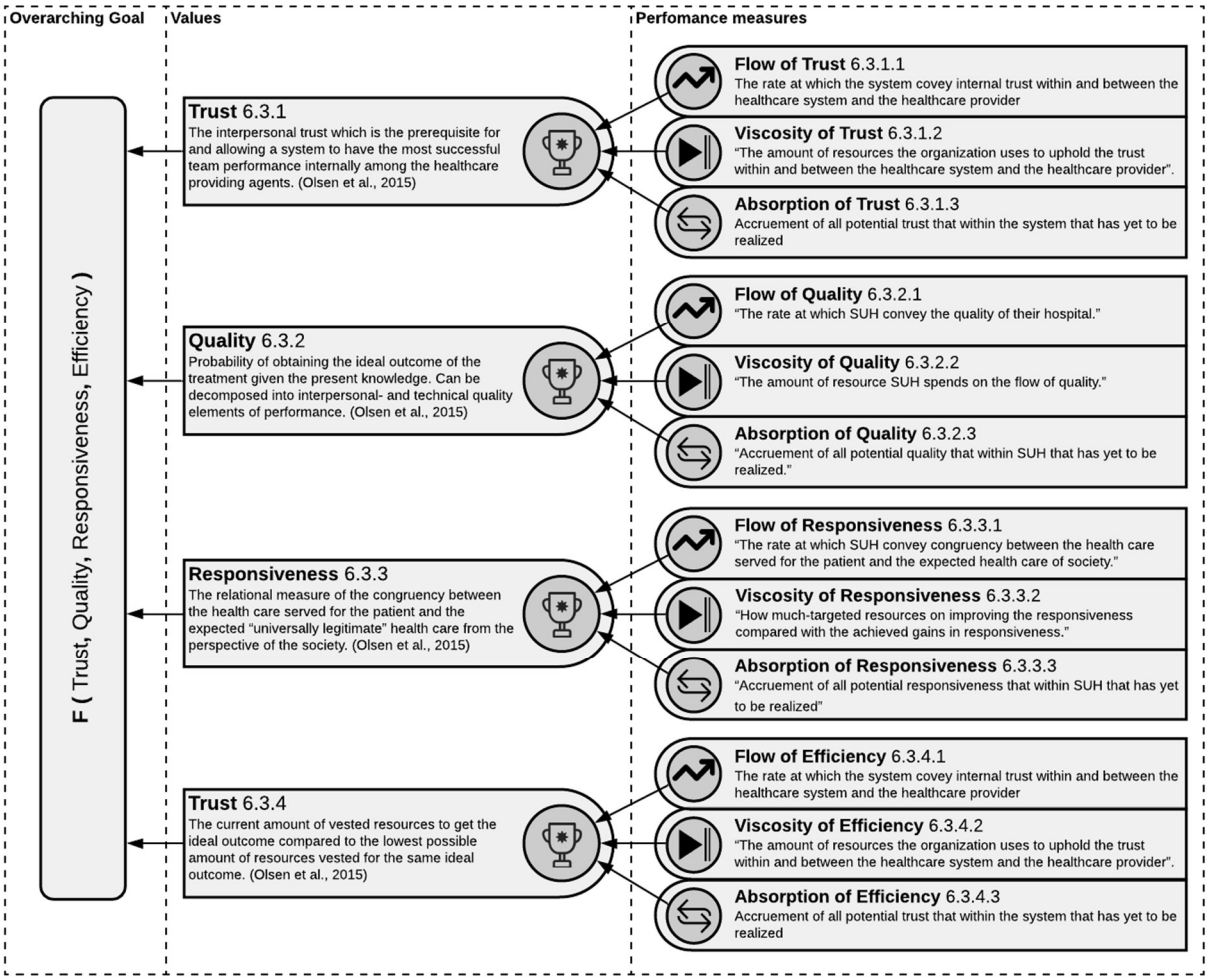


Figure 6.10 – Summarizing flow chart of the developed value structure, with the connection between the overarching goal, all SUH's values, and performance measures.

Summary of Chapter

This chapter has performed the conceptual implementation of the value structure that was transformed and modified in CHAPTER 5 to underpin the values of SUH. This is then the logical conclusion of the last step in the process of transformation on the ACAP-model presented in SUBCHAPTER 3.1 as the methodological structure for this dissertation. The next step is to carry out the exploitation-step, which imply carrying out this framework in the organization of SUH. However, this is beyond the scope of this dissertation as the goal here was to perform it out conceptually and stipulate the implementation of the abstracted value structure from SUBCHAPTER 5.1-3.

Main takeaways from subchapters;

Several elements have been brought throughout the subchapters of this chapter. Following is a list of what is wanted for the reader to have as the main takeaways from each of the subchapters.

- SUBCHAPTER 6.1; Abstracted value structure provides leeway to circumvent unidimensionality in the overarching goal and makes room for soft values.

- SUBCHAPTER 6.2; Review of the four core values for SUH before implementation.

- SUBCHAPTER 6.3; The values got implemented along with examples of use of the five focusing steps.

Chapter 7: Discussion

This chapter is going the undergo the elements of the result of the project in this dissertation and reflect on its limitation and what that could be avenues for further refinement of this project.

7.1.1 Assumptions

Theory of constraints

This whole dissertation is based on the premise that TOC has at the core, something that is worthwhile for the public hospital. This might still be an open question, as we have seen in SUBCHAPTER 4.4, there has not been found an actual implementation of the value structure of TOC holistically into the full organization. It might be possible that the performance measure (and the abstracted, for that matter) will only promote profit maximization, these softer values

Another question about TOC is if its actually a good theory. Naor et al. point out that this has been up to debate in the article "Theory of constraints: is it a theory and a good one?"(Naor et al., 2013). Naor et al. discuss the theoretical goodness of TOC. And in their analysis, they conclude that TOC fits the criteria of being a "good" theory. However, it could be a flawed method that is used, and perhaps its cherry-picked only because it fits TOC the best.

However, TOC-principles emerged simultaneously from two spheres; Load Oriented Manufacturing Control (presented in SECTION 4.1.4) and TOC. The fact that the principles have emerged from two places; one practical and one academic might be a testimony showing that the theory has merits regardless.

The positioning of the value structure as the axiom of TOC

In SUBCHAPTER 5.1, there was imposed the placement of the value structure to be placed as the fundamental axiom. This could be not the wrong move (despite the arguments that were provided to do so), this is based on the personal interpretation and could be subject to dispute. An otherwise case could be that some (or one) of the methods (e.g., the five focusing steps)

should be put as the fundamental axiom and everything else should be viewed as means underpinning that or those methods.

Value Structure of TOC

The assumption that what's in the core of TOC (i.e., the value structure) that is worthwhile and not the surrounding tools. It could be that the reality is the total opposite; that the value structure will not fit the public hospital sector at all, but that its primarily the constituent tools of TOC that is of any use. If nothing else; this is an argument by consensus because what was shown in SUBCHAPTER 4.4, there was only a small minority of the articles that had taken use of the value structure. However, my contention is that the reasoning presented in SUBCHAPTER 4.4 and 5.1-2 is valid and that if one should call it "TOC-implementation" one should include the performance measures to validate the initiatives.

Assumption of the overarching method of this dissertation

The exploratory method (ACAP process presented in CHAPTER 3) of this project was backed up by a theory that in its form was intended for another purpose. There could have been done more thorough research exploring alternative knowledge transfer theories that could have yielded even better results. One challenge with such kind of research is that there is no concrete set of vocabulary, and the one can look up, as these frameworks seemingly appear in different fields of knowledge. However, the resulting outcome from this chosen framework has been invaluable as a verification of the legitimacy of the processes along the way of this project. At the same time, this utility does not remove the fact that the selected method might be biased because of the chance it could be the case that there exists a framework that could substantiate and guide the project better.

7.1.2 Limitations

This section will point out some of the limitation the resulting project has.

Strategical and Operational Level

The content of this analysis (CHAPTER 5 and 6) has been mostly concerned about the organization's strategy and mission (i.e., the strategical and administrative level of the hospital) and not so much about what the workers should do in practice.

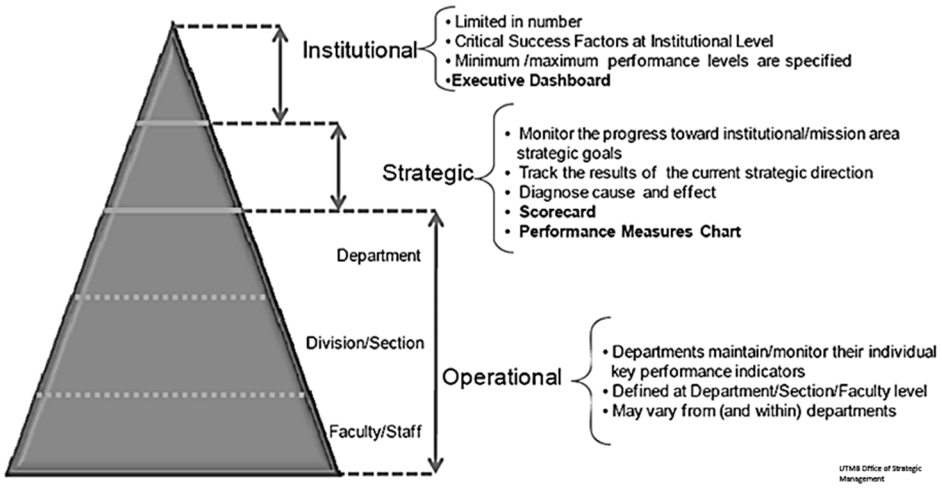


Figure 7.1 – Hierarchy of the performance measures v. institutional levels (UTMB, n.d.).

The stated values from SUH is values that generally is chosen on the administrative level of the organization. As it is now the suggested framework is presented up until now, they might be hard to not so illuminative for the detailed work in the wards. SUH and other hospitals operate on several key performance indexes (KPI). This result of this project did not tie the work together with the typical KPI's, although some were suggested in SUBCHAPTER 6.3.

Reflection Around the Construct of Multidimensional Goal

In SUBCHAPTER 6.2, this work there was a suggestion on how to conceptualize having several goals (the four core values of SUH) at once. This was done to shoe-horn TOC so that it would fit the goals of SUH or the triple aim of IHI. This might be problematic to have several goals at one time as it might be hard to orient the whole organization towards more than one goal. And is it even possible to ask every agent to in all of their micro-decision to direct their decisions towards the optimal combination of four dimensions at once? This could be impossible to make out in practice.

This problem might be worked around by keeping the several goals only at the administrative (strategic) level and perhaps only delegate one of the goals to the operational level. Doing this will let the administration keep accountancy of the sum of goals and at the same time avoid the inefficiencies caused by confusion and

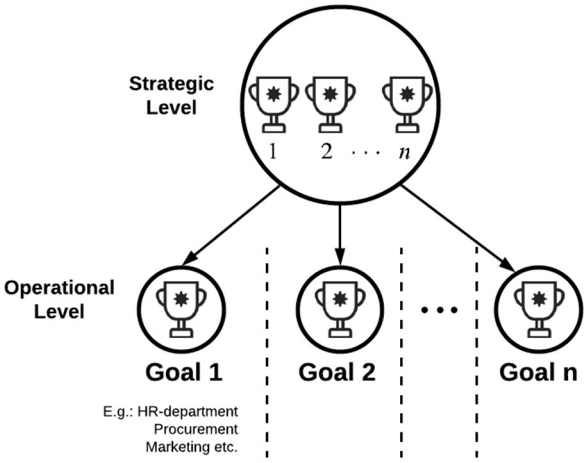


Figure 7.2 – Delegating the goals to different departments might solve problem with goal dilution.

Limitation on Operational Implications

This work is not about how to make a good strategic plan; it's about how to carry out the strategic values of SUH. To initiate the change to this proposed framework would be a large project and should involve assessments on how such a change would impact the day-to-day operation in SUH.

Problems with the Abstraction

Human arbitrariness bedeviled for biased actions this is especially the case when articulating a deeper substructure that might have a nearly infinite number of interpretations. As there will always exist human arbitrariness in both the interpretation of TOC and in the reconstruction of the abstracted version of TOC. For example; it could be the case that the use of funnel-analogy at this extent was a dead end. And it should be an analogy that hade more possibility for detail to it.

Limitation on interpretation of the SUH values

It might be that the defined goal of SUH might not fit to this constructed framework and they might would be defined differently if the context of the presented framework was in mind during the process of coming up with them. However, this framework does not favor any types of goal, it's just an attempt on making a framework on how to sanely achieve the goals whatever those goals constitutes

7.1.3 Further work

This section will point to a places that could be worked on in the future to expand this project.

Weighting of the individual values

As only hinted to in the illustration of the proposed, there was writing "f(….)" this because it could be the case that it is possible to juxtapose the achievement of the individual values in a function. This would, however, necessitate a form of weighting the values against each other (e.g., x1 * Trust + x2 * Efficiency …). This should be an avenue for further research as this would give judgment if an initiative is a net good or not. As an initiative could make the minor lowering of, e.g., efficiency but give a vast improvement in the value of trust. If done correctly (given that it is possible to carry out) one could justify further initiatives like that even though it suffers on the efficiency.

Feedback loop

A way of updating the operationalization (proposed in 6.3.5) should be considered as it is highly unlikely that the first attempt gives a perfect solution. It might actually be the case that a static value definition is unwanted. This could be done by developing a framework to just to that; measuring the outcome to see if the values yielded the intended outcome and adjust the values accordingly.

One-dimensional overarching goal

Since the concretizing of a definitive one-dimensional goal for non-for-profit has yet to be done, it should be done a thorough investigation effort into such an attempt. It could be the case that it is possible to article such a goal without involving the strategical core values as goals. Albeit, if it is possible to find, it should be in some ways customizable for the individual hospital so that the hospital can adjust it to theirs. (this suggestion is not so much tied to the resulted framework, but a suggestion in general)

Expanding to other Operations Management Methodologies

SUBSECTION 4.1.3.1 presented the concept of synergic variants of OM-methodologies. It could be reasonable that the different values would be promoted by the use of different OM-methodologies. E.g., the value of "Quality" could, in fact, be better promoted by the use of Six Sigma (shown in SECTION 4.1.3). It could be the case that the abstraction of the value structure

of TOC has done so that it does not matter what OM-methodology that is used. As long as it's the same methodology for each of the values.

Expanding conception of flow

like seen in the implementation of the performance measures onto the SUH's values SUBCHAPTER 6.3 there is many different ways of conceptualizing flow in a hospital. The conceptualizations are instrumental and unique. Depending on the accuracy of measuring techniques, and depending on how rigid such a relation can be established, this could be a great avenue for further research. There might be found that there is a nearly infinite number of conceptualizations. However, these could be ranked and delineated according to the how "good" they convey a constraint in the system. A start for this could be investigating the relationship between the four types of constraints (see the four different types in SECTION 4.3.2) and different types of interpretations of flow throughout the hospital.

Chapter 8: Conclusion

The goal of this dissertation was based on the identified societies' insatiate need for health care across the population to attempt to adjust the fruitful theory that has proven utility in the industry sector. The project of the dissertation has endeavored an attempt to fill the theoretical gap that has abstained the healthcare improvement community from using Theory of Constraints in their improvement processes.

By using the ACAP's process view (SUBCHAPTER 3.1) as an overarching methodological approach, this substantiated this dissertation's project in particular, by structuring a way of carrying out the project in a systematic way. First, through thorough assimilation (explained in SUBSECTION 3.1.1.3) through the theory part of this dissertation (CHAPTER 4) where the general theoretical landscape of operations management was reviewed. Here it was also performed a literature review of the past performed TOC-implementations to pinpoint the problem in the past implementation in the hospital setting.

This assimilation process yielded several insight, apart from being instrumental in providing the theory. Among those, it yielded the insight on what type of barriers a transformation of a operations management needs to pass through in order to expand its utility over to publicly funded healthcare sector. This conceptualization led to the next yield that allowed for a precise categorization of the past articles so that it was possible to see which articles, this allowed to find what was done before and to precisely locate what was the problem in the past implementations.

Next, through the transformation process of the ACAP process (explained in SUBSECTION 3.1.1.4) the project in the analysis part first transformed the value structure of the Theory of constraints (CHAPTER 5) to an abstract level then, it got placed into an analogy providing firm re-interpretation for future implementations.

This transformation was based on the theoretical claim in the Theory of Constraint that the performance measures is all that is needed to know if an organization is moving towards its

goal or not (4.3.2-5). The abstraction of the value structure of the Theory of constraints conceptually provided the allowance to implement into the public hospital sector.

In addition resulting framework has the allowance for several simultaneous goals (SECTION 6.1.2), which is beneficial for an organization that cant operate solely on maximizing profit and needs to have goals in addition to that. Another quality of the resulting framework is that it provides acceptance of leadership values such as trust, depending on the measuring techniques in those fields of study.

The problem statement and goal of this dissertation (SECTION 2.3.1-2) is provided a conceptually. Both through the general but also through an illustrative example of a publicly funded hospital.

Contributions

Following is the pointing out of the contributions of this project. The primary contributions are regarded as outcomes of the project and the secondary contributions that served as a means to get those outcomes. However, they were not found in the literature.

The primary contribution of this project is the following;

- The generalization of the value structure of the Theory of Constraint for its extended usage onto organization with a value-based or non-profit modus operandi (CHAPTER 5).
- Exemplification of use of the generalized value structure for the core values of a public hospital; SUH (CHAPTER 6).

Secondary contributions of this project;

- A novel way of utilizing the ACAP-process in the context of a dissertation (explained in CHAPTER 3, contained in CHAPTER 4-6).
- Conceptualization of the barriers that hinder operations management methodologies from underpinning the public hospital sector (SECTION 4.2.2).
- The conceptual situating of the three abstract performance measures into a funnel analogy (SUBCHAPTER 5.3).
- Proposing adjustment of the value structure of TOC to allow for soft-values and proposing how to allow several simultaneous goals at once.

- Evaluation criteria for distinguishing implementations are surpassing those three barriers from those that don't (SECTION 4.4.1) and reviewing the articles through these categorical lenses.

Because the project in this dissertation was conceptual, the contribution of this project is theoretical contributions at this stage. However, it is a wish for this to be a practical contribution in the future by working personally together and along with SUH in the future.

Appendix

A.1 – List of References

Following is the list of the sources that are consulted with to underpin elements of this dissertation:

Aguilar-Escobar, V.-G., Garrido-Vega, P., & Gonzalez-Zamora, M.-M. (2016). Applying the theory of constraints to the logistics service of medical records of a hospital. *European Research on Management and Business Economics*, *22*(3), 139–146. https://doi.org/10.1016/j.iedee.2015.07.001

Barney, M. (2002). *Motorola's Second Generation*. 5.

Bechte, W. (1988). Theory and practice of load-oriented manufacturing control. *International Journal of Production Research*, *26*(3), 375–395. https://doi.org/10.1080/00207548808947871

Breithaupt, J.-W., Land, M., & Nyhuis, P. (2002). The workload control concept: Theory and practical extensions of Load Oriented Order Release. *Production Planning & Control*, *13*(7), 625–638. https://doi.org/10.1080/0953728021000026230

Cattaneo, C., & Bassani, G. (2016). The TOC Thinking Process: The viability of change. *Human Systems Management*, *35*(4), 301–323. https://doi.org/10.3233/HSM-161616

Cox, J. F., & Schleier, J. G. (2010). *Theory of constraints handbook*. Retrieved from http://accessengineeringlibrary.com/browse/theory-of-constraints-handbook

Crawford-Mason, C. (2002). Deming and me. *Quality Progress; Milwaukee*, *35*(9), 45–48.

Criddle, J., & Holt, J. (2018). Use of Simulation Software in Optimizing PACU Operations and Promoting Evidence-Based Practice Guidelines. *Journal of PeriAnesthesia Nursing*, *33*(4), 420–425. https://doi.org/10.1016/j.jopan.2017.03.004

Davis, K., Stremikis, K., Squires, D., & Schoen, C. (2014). *MIRROR, MIRROR ON THE WALL - How the Performance of the U.S. Health Care System Compares Internationally*. 32.

de Souza, M. C., Souza, T. A., & Vaccaro, G. L. R. (2016). Hospital bed management: An analysis from the perspective of the theory of constraints. *Espacios*, *37*(30). Retrieved from Scopus.

Dettmer, H. W. (1997). *Goldratt's Theory of Constraints: A Systems Approach to Continuous Improvement*. ASQ Quality Press.

FocusEconomics. (2018, 8). The Richest Countries in the World (2017-2022). Retrieved March 19, 2019, from FocusEconomics | Economic Forecasts from the World's Leading Economists website: https://www.focus-economics.com/blog/richest-countries-in-the-world

fxtop.com. (2019, February 7). Currency converter in the past with official exchange rates from 1953. Retrieved February 7, 2019, from http://fxtop.com/en/currency-converter-past.php?A=6600000000&C1=NOK&C2=USD&DD=07&MM=02&YYYY=2019&B=1&P=&I=1&btnOK=Go%21

Gallagher Healthcare. (2018, 03). What Are the Different Types of Hospitals? Retrieved February 14, 2019, from https://www.gallaghermalpractice.com/blog/post/what-are-the-different-types-of-hospitals

Gassmann, O., & Zeschky, M. (2008). Opening up the Solution Space: The Role of Analogical Thinking for Breakthrough Product Innovation. *Creativity and Innovation Management*, *17*(2), 97–106. https://doi.org/10.1111/j.1467-8691.2008.00475.x

Giunchiglia, F., & Walsh, T. (1992). A theory of abstraction. *Artificial Intelligence*, *57*(2–3), 323–389. https://doi.org/10.1016/0004-3702(92)90021-O

Goldratt, E. M. (1984). *The Goal: A Process of Ongoing Improvement* (30th Anniversary Edition edition). Great Barrington, Mass: North River Press.

Goldratt, E. M. (1999). *What is this thing called THEORY OF CONSTRAINTS and how should it be implemented?* (1 edition). Great Barrington, Massachusetts: North River Pr.

Goldratt, E. M. (2006). *Standing on the shoulders of Giants - Production concepts versus production applications The Hitachi Tool Engineering Example*. Retrieved from https://www.goldrattconsulting.com/webfiles/fck/files/Standing-on-the-Shoulders-of-Giants.pdf

Google Ngram. (2019). Google Ngram Viewer - TOC, Lean Management and Six Sigma. Retrieved February 14, 2019, from https://books.google.com/ngrams/graph?content=Theory+of+constraints%2C%22Six+Sigma%22%2CLean+Management&year_start=1984&year_end=2008&corpus=17&smoothing=1&share=&direct_url=t1%3B%2CTheory%20of%20constraints%3B%2Cc0%3B.t1%3B%2C%22%20Six%20Sigma%20%22%3B%2Cc0%3B.t1%3B%2CLean%20Management%3B%2Cc0

Groop, J., Ketokivi, M., Gupta, M., & Holmström, J. (2017). Improving home care: Knowledge creation through engagement and design. *Journal of Operations Management*, *53–56*, 9–22. https://doi.org/10.1016/j.jom.2017.11.001

Gupta, M. C., Bridgman, S., & Kaur Sahi, G. (2015). Application of TOC-based framework to improve market orientation in a non-profit organization. *Journal of Strategic Marketing*, *23*(7), 579–599. https://doi.org/10.1080/0965254X.2014.1001865

Gupta, M. C., Sahi, G. K., & Chahal, H. (2013). Improving market orientation: The theory of constraints-based framework. *Journal of Strategic Marketing*, *21*(4), 305–322. https://doi.org/10.1080/0965254X.2013.790467

Gupta, M., & Kline, J. (2008). Managing a community mental health agency: A Theory of Constraints based framework. *Total Quality Management & Business Excellence*, *19*(3), 281–294. https://doi.org/10.1080/14783360701601850

Hayakawa, S. I. (1972). *Language in thought and action* (3rd edition). New York: Harcourt Brace Jovanovich.

Heizer, J., Render, B., & Munson, C. (2017). *Operations management: Sustainability and supply chain management* (Twelfth edition). Boston: Pearson.

Huang, W.-T., Chen, P.-S., Liu, J. J., Chen, Y.-R., & Chen, Y.-H. (2018). Dynamic configuration scheduling problem for stochastic medical resources. *Journal of Biomedical Informatics*, *80*, 96–105. https://doi.org/10.1016/j.jbi.2018.03.005

Hunink, M. G. M. (2001). In Search of Tools to Aid Logical Thinking and Communicating about Medical Decision Making. *MEDICAL DECISION MAKING*, *21*(4), 11.

Huse Amundsen, I. (2013, 09). Sykehuslegene fanget i papirmølla. Retrieved May 7, 2019, from https://www.vg.no/i/4945V

IHI - Senior Fellows. (n.d.). Institute for Healthcare Improvement: IHI Senior Fellows. Retrieved June 1, 2019, from http://www.ihi.org:80/about/Pages/IHISeniorFellows.aspx

III, A. L., & Spencer, M. S. (1998). Performance measurement in a theory of constraints environment. *International Journal of Production Research*, *36*(8), 2045–2060. https://doi.org/10.1080/002075498192760

J. Johnsen, O., & Brynhildsen, R. (2018, May 29). Får ikke mer tid til pasienten. Retrieved May 7, 2019, from dmag website: https://dmag.no:443/far-ikke-mer-tid-til-pasienten/

Jonas, S., McCay, L., & Keogh, S. B. (2017). The Importance of Clinical Leadership. In *ABC of Clinical Leadership* (p. 101). John Wiley & Sons.

Kemper, B., & de Mast, J. (2013). Measurement Plans for Process Flow Improvement in Services and Health Care. *Quality Engineering*, *25*(4), 437–450. https://doi.org/10.1080/08982112.2013.805779

Knight, A. (2015). *Pride and Joy* (1th Editition). Never Say I Know.

Kohn, L. T., Corrigan, J., & Donaldson, M. S. (2000). *To err is human: Building a safer health system*. Retrieved from http://site.ebrary.com/id/10038653

Korzybski, A. (1995). *Science and Sanity: An Introduction to Non-Aristotelian Systems and General Semantics* (5th edition). Brooklyn, N.Y: Institute of General Semantics.

Lang, D. L. (n.d.). The Goal book by Eliyahu Goldratt. Retrieved February 11, 2019, from https://www.velocityschedulingsystem.com/blog/goal-book-eliyahu-goldratt/

Leseure, M. (2010). *Key Concepts in Operations Management* (1 edition). Los Angeles: SAGE Publications Ltd.

Leskela, R.-L., Herse, F., Torkki, P., Laine, J., Vilkuna, T., & Raatikainen, T. (2016). Analysis of the adoption of new health technology: The case of Dupuytren's disease. *International Journal of Healthcare Technology and Management*, *15*(3), 210–227. https://doi.org/10.1504/IJHTM.2016.078360

Liphadzi, M., Aigbavboa, C. O., & Thwala, W. D. (2017). A Theoretical Perspective on the Difference between Leadership and Management. *Procedia Engineering*, *196*, 478–482. https://doi.org/10.1016/j.proeng.2017.07.227

Mabin, V. J., & Balderstone, S. J. (2003). The performance of the theory of constraints methodology: Analysis and discussion of successful TOC applications. *International Journal of Operations & Production Management; Bradford*, *23*(5/6), 568.

Mabin, V., Yee, J., Babington, S., Caldwell, V., & Moore, R. (2018). Using the Theory of Constraints to resolve long-standing resource and service issues in a large public hospital. *Health Systems*, *7*(3), 230–249. https://doi.org/10.1080/20476965.2017.1403674

MacDonald, S. L., Cowan, I. A., Floyd, R., Mackintosh, S., Graham, R., Jenkins, E., & Hamilton, R. (2013). Measuring and managing radiologist workload: Application of lean and constraint theories and production planning principles to planning radiology services in a major tertiary hospital. *Journal of Medical Imaging and Radiation Oncology*, *57*(5), 544–550. https://doi.org/10.1111/1754-9485.12090

Mast, J. de, Kemper, B., Does, R. J. M. M., Mandjes, M., & Bijl, Y. van der. (2011). Process improvement in healthcare: Overall resource efficiency. *Quality and Reliability Engineering International*, *27*(8), 1095–1106. https://doi.org/10.1002/qre.1198

Meadows, D. H., & Wright, D. (2009). *Thinking in systems: A primer*. London [u.a.]: Earthscan.

Muriki, S. (2012, October 27). Compare and Contrast Lean, Six Sigma and Theory of Constraints (Article). Retrieved February 26, 2019, from http://ilstupm.blogspot.com/2012/10/compare-and-contrast-lean-six-sigma-and.html

Mur-Veeman, I., & Govers, M. (2011). Buffer management to solve bed-blocking in the Netherlands 2000–2010. Cooperation from an integrated care chain perspective as a key success factor for managing patient flows. *International Journal of Integrated Care*, *11*(Special 10th Anniversary Edition). Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3180700/

Nagarkatte, U., & Oley, N. (2018). *Theory of constraints: Creative problem solving*. Boca Raton: CRC Press, Taylor & Francis Group.

Naor, M., Bernardes, E. S., & Coman, A. (2013). Theory of constraints: Is it a theory and a good one? *International Journal of Production Research*, *51*(2), 542–554. https://doi.org/10.1080/00207543.2011.654137

Nave, D. (2002). How to compare Six Sigma, lean and the theory of constraints. *Quality Progress; Milwaukee*, *35*(3), 73–78.

Nestsiarovich, A., Hurwitz, N. G., Nelson, S. J., Crisanti, A. S., Kerner, B., Kuntz, M. J., … Lambert, C. G. (2017). Systemic challenges in bipolar disorder management: A patient-centered approach. *Bipolar Disorders*, *19*(8), 676–688. https://doi.org/10.1111/bdi.12547

Netland, T. H. (2013). *Company-specific production systems: Managing production improvement in global firms* (Norges teknisk-naturvitenskapelige universitet, Fakultet for samfunnsvitenskap og teknologiledelse, Institutt for industriell økonomi og teknologiledelse). Retrieved from https://brage.bibsys.no/xmlui/handle/11250/266418

Olsen, Ø. E., Husebø, S. E., Qvindesland, S. A., & Lorentzen, H. (2015). Redefining clinical leadership for team-course development. *Journal of Hospital Administration*, *4*(5), p52. https://doi.org/10.5430/jha.v4n5p52

Pacheco, D. (2015). TOC, lean and six sigma: The missing link to increase productivity? *Academic Journals*, *9*(12). https://doi.org/10.5897/AJBM2014.7672

Patwardhan, M. B., Sarría-santamera, A., & Matchar, D. B. (2006). Improving the process of developing technical reports for health care decision-makers: Using the Theory of Constraints in the Evidence-Based Practice Centers. *International Journal of Technology Assessment in Health Care; Cambridge*, *22*(1), 26–32.

Pawlak, R. (2016). Theory of Constraints What Can We Learn to Support the Nursing Workforce? *Journal of Nursing Administration*, *46*(11), 558–560. https://doi.org/10.1097/NNA.0000000000000404

Pergher, I., Brandolf, V. P., Pacheco, D. A. de J., & Vaccaro, G. L. R. (2016). A patient-centric approach to improve health care services. *Cogent Business & Management*, *3*(1), 1227232. https://doi.org/10.1080/23311975.2016.1227232

Pinnacle Strategies. (n.d.). TLS -Theory of Constraints Lean, Six Sigma. Retrieved March 11, 2019, from – Pinnacle Strategies website: http://pinnacle-strategies.com/resources/tls-theory-of-constraints-lean-six-sigma/

Plossl, G. W. (1983). *Production and Inventory Control: Applications* (First Edition edition). Marietta, Ga: George Plossl Educational Serv.

Plossl, G. W. (1985). *Production and Inventory Control: Principles and Techniques* (2 edition). Englewood Cliffs, NJ: Pearson.

Pretorius, P. (2014). Introducing in-between decision points to TOC's five focusing steps. *International Journal of Production Research*, *52*(2), 496–506. https://doi.org/10.1080/00207543.2013.836612

Proff.no. (2018). Stavanger Universitetssjukehus Administrasjon og Støttefunksjoner - Stavanger - Se Regnskap, Roller og mer. Retrieved February 7, 2019, from https://www.proff.no/selskap/stavanger-universitetssjukehus-administrasjon-og-st%C3%B8ttefunksjoner/stavanger/hovedkontortjenester/IF8WUI810NZ/

Rahman, S. (1998). Theory of constraints: A review of the philosophy and its applications. *International Journal of Operations & Production Management*, *18*(4), 336–355. https://doi.org/10.1108/01443579810199720

Rawson, J. V., Kannan, A., & Furman, M. (2016). Use of Process Improvement Tools in Radiology. *Current Problems in Diagnostic Radiology*, *45*(2), 94–100. https://doi.org/10.1067/j.cpradiol.2015.09.004

Røhme, K., & Kjekshus, L. E. (2001, 05). Når tiden telles – sykehuslegers tidsbruk og arbeidsoppgaver. Retrieved May 7, 2019, from Tidsskrift for Den norske legeforening

website: https://tidsskriftet.no/2001/05/klinikk-og-forskning/nar-tiden-telles-sykehuslegers-tidsbruk-og-arbeidsoppgaver

Ronen, B., & Pass, S. (2008). *Focused operations management: Achieving more with existing resources*. Hoboken, N.J: Wiley.

Ronen, B., Pliskin, J. S., & Pass, S. (2006). *Focused Operations Management for Health Services Organizations* (1 edition). San Francisco, CA: Jossey-Bass.

Ronen, B., Pliskin, J. S., & Pass, S. (2018). *The Hospital and Clinic Improvement Handbook: Using Lean and the Theory of Constraints for Better Healthcare Delivery*. Oxford ; New York: Oxford University Press.

Rotstein, Z., Wilf-Miron, R., Lavi, B., Seidman, D. S., Shahaf, P., Shahar, A., … Noy, S. (2002). Management by constraints: Considering patient volume when adding medical staff to the emergency department. *Israel Medical Association Journal*, *4*(3), 170–173.

Roybal, H., Baxendale, S. J., & Gupta, M. (1999, Winter). Using activity-based costing and theory of constraints to guide continuous improvement in managed care. *Managed Care Quarterly; Frederick*, *7*(1), 1–10.

Rutherford, P. A., Provost, L. P., Kotagal, U. R., Luther, K., & Anderson, A. (2017). *Institute for Healthcare Improvement: Achieving Hospital-wide Patient Flow*. Retrieved from http://www.ihi.org:80/resources/Pages/IHIWhitePapers/Achieving-Hospital-wide-Patient-Flow.aspx

Sadat, S., Carter, M. W., & Golden, B. (2013). Theory of constraints for publicly funded health systems. *Health Care Management Science; New York*, *16*(1), 62–74. http://dx.doi.org/10.1007/s10729-012-9208-9

Sahraoui, A., & Elarref, M. (2014). Bed crisis and elective surgery late cancellations: An approach using the theory of constraints. *Qatar Medical Journal*, *2014*(1). https://doi.org/10.5339/qmj.2014.1

Schaefers, J., Colin, J., Aggoune, R., & Kucina, M. (2007). A contribution to performance measurement in the healthcare industry: The industrial point of view. *International Journal of Business Performance Management*, *9*(2), 226–239. https://doi.org/10.1504/IJBPM.2007.011864

Schrijvers, G., van Hoorn, A., & Huiskes, N. (2012). The care pathway: Concepts and theories: an introduction. *International Journal of Integrated Care*, *12*.

Shapiro, A. N., & Dietz, J. (n.d.). About Eliyahu M. Goldratt | Biography | Physicist, Economist, Engineer, Writer | Israel | UpClosed [UpClosed]. Retrieved February 11, 2019, from https://upclosed.com/people/eliyahu-m-goldratt/

Slack, N., Chambers, S., & Johnston, R. (2009). *Operations management* (5. ed., [Nachdr.]). Harlow: Prentice Hall/Financial Times.

SSB.no. (2018, March 14). NOK 65 000 spent on health per capita. Retrieved February 11, 2019, from ssb.no website: https://www.ssb.no/en/nasjonalregnskap-og-konjunkturer/artikler-og-publikasjoner/nok-65-000-spent-on-health-per-capita

Stratton, R., & Knight, A. (2010). Managing patient flow using time buffers. *Journal of Manufacturing Technology Management*, *21*(4), 484–498. https://doi.org/10.1108/17410381011046599

SUH, H. (2018). Key figures 2018. Retrieved February 14, 2019, from Helse Stavanger website: https://helse-stavanger.no/om-oss/nokkeltall-2018

SUH, H. (2019). Om oss. Retrieved February 7, 2019, from Helse Stavanger website: https://helse-stavanger.no/om-oss

Terning, G., Aallontie, J., Lande, I., & Ali, J. (2018). *Industry 4.0 Implementation in Hospitals Medicine Stock Operations (Essay 3 of 3, In Course MØA255 - Supply Chain & Lean Management at UiS)* (Essay). University of Stavanger.

Thurer, M., Stevenson, M., & Renna, P. (2019). Workload control in dual-resource constrained high-variety shops: An assessment by simulation. *International Journal of Production Research*, *57*(3), 931–947. https://doi.org/10.1080/00207543.2018.1497313

TOC-Goldratt.com. (n.d.). Biography of Dr. Eliyahu M. Goldratt | Theory of Constraints Focus. Retrieved February 11, 2019, from https://www.toc-goldratt.com/tocweekly/biography-of-dr-eliyahu-m-goldratt/

Tomolo, A., Burton-Houle, T., & Aron, D. (2002). Applying the Theory of Constraints in Health Care: Part 1—The Philosophy. *Quality Management in Health Care*, *10*, 40–46. https://doi.org/10.1097/00019514-200210030-00010

Trickey, H., & Newburn, M. (2014). Goals, dilemmas and assumptions in infant feeding education and support. Applying theory of constraints thinking tools to develop new priorities for action. *Maternal & Child Nutrition*, *10*(1), 72–91. https://doi.org/10.1111/j.1740-8709.2012.00417.x

Umble, M., & Umble, E. J. (2006). Utilizing buffer management to improve performance in a healthcare environment. *European Journal of Operational Research*, *174*(2), 1060–1075. https://doi.org/10.1016/j.ejor.2005.02.059

UTMB. (n.d.). Hierarchy of Performance Measures | The Office of Strategic and Business Planning | UTMB Home. Retrieved June 28, 2019, from Hierarchy of Performance Measures | The Office of Strategic and Business Planning | UTMB Home website: https://www.utmb.edu/osm/strategic-framework/hierarchy-of-performance-measures

van Harten, W. H., Goedbloed, N., Boekhout, A. H., & Heintzbergen, S. (2018). Implementing large scale fast track diagnostics in a comprehensive cancer center, pre- and post-measurement data. *BMC Health Services Research*, *18*(1), 85. https://doi.org/10.1186/s12913-018-2868-5

Verma, A., Lee, M. Y., Wang, C., Hussein, N. B. M., Selvi, K., & Tee, A. (2014). Efficiency of performing pulmonary procedures in a shared endoscopy unit: Procedure time, turnaround time, delays, and procedure waiting time. *Journal of Bronchology and Interventional Pulmonology*, *21*(2), 135–141. https://doi.org/10.1097/LBR.0000000000000050

Wanderer, R. (2007). General Semantics: A Compendium of Definitions. *ETC: A Review of General Semantics*, *64*(3), 193–204.

Wiendahl, H.-P. (1995). *Load-Oriented Manufacturing Control*. https://doi.org/10.1007/978-3-642-57743-7

Womack, D. E., & Flowers, S. (1999). Improving system performance: A case study in the application of the theory of contraints. *Journal of Healthcare Management; Chicago*, *44*(5), 397–405; discussion 405-7.

Womack, J. P., Jones, D. T., & Roos, D. (1990). *The Machine That Changed the World - The Story of Lean Production -- Toyota's Secret Weapon in the Global Car Wars That Is Now Revolutionizing World Industry* (Vol. 1). 866 Third Arcnue, Nrw York, N.Y. IOOLZ: RAWSON ASSOCIATES - Macmilkin Publishing Company.

Wu, F., Jia, T., Liu, S. L., & Qi, J. Y. (2009). The analysis of service station allocation in the hospital based on bottleneck model. *International Journal of Services, Technology and Management*, *12*(2), 231–251. https://doi.org/10.1504/IJSTM.2009.025236

Zahra, S. A., & George, G. (2002). ABSORPTIVE CAPACITY: A REVIEW, RECONCEPTUALIZATION, AND EXTENSION. *Academy of Management Review*, *27*(2), 185–203.

A.2 – List and categorization of reviewed articles

List of Categorization of Results from Search in databases

There were performed a literature review (SUBCHAPTER 4.4) […]. Following is the list of the article authors, article names, journal, etc. for those articles undergone in the review. These are not necessarily used as sources for the dissertation, those that are have their proper reference in the source list above.

Additional Categories

In addition to the primary categories presented in SUBCHAPTER 4.4, the articles were also judged on the following secondary criteria. These were not summarized as the two previous as these were not as important. However, each article was appointed to these, and their belonging category is indicated in APPENDIX A.2.

Function of Article

Besides the two primary categories, there was an interest of categorizing the articles into what type of organization the suggested (and/or implemented) initiatives was evaluated in. Articles found to be aimed at publicly funded institutions or found to be aimed at both private and public-sector was categorized as "non-profit." Articles that was based on research cases exclusive for for-profit context got categorized as "for-profit." The reason why this was interesting is that non-profits might have struggled to use the theory as it is presented in the original literature. A second functional criterion was seemed to be useful; whether or not the article was purely descriptive or normative in its nature.

Categories of Consistency;

There was found some logical error at the application of TOC. This was partly a consequence of the mix of the different incompatible categories of application (core at) and partly caused insufficiency in the measurement system was set up.

> **Consistent**; applications of TOC where all measures are taken into consideration for evaluation in an initiative was confirmed as being an improvement of the system or not.

Inconsistent; One or two performance measures are omitted, according to TOC one cannot know if the outcome of an initiative should be regarded as a betterment (improvement) without taking all of them (throughput - T, operational expenses - OE, inventory - I) into consideration.

Note; This is not to "doom" the initiative effective/ineffective it's just to say that one cannot *know* if the initiative can be categorized as being an "improvement" according to TOC (consult SUBCHAPTER 4.3 for an explanation of "improvement" according to TOC). Articles that have not evaluated any of the performance measures are not here considered to be "inconsistent" even though this constitutes a strict criterion to fulfill. Within each article, there a lot more wheat than chaff; however, when looking mostly at the execution of the core of TOC, the picture gets opposite. Because of the goal here is to evaluate only the implementation of the core.

Review and Categorization of the Articles

Web of Science:

1. **Womack DE, Flowers S. Improving system performance: A case study in the application of the theory of constraints. *Journal of Healthcare Management; Chicago*. 1999;44(5):397-405; discussion 405-7.**

Note; Case study of TOC used in U.S. Air Force in Mountain Home Air Force Base in a rural part of Idaho. Applied TOC-concepts; 5 principles for guidance, and five focusing steps (FFS) to improve the scheduling process, flow charts applied for locating constraint in the patient encounter process. Reports "dramatically" increased throughput (T) while without significant cost increase (OE).

Comment; Reports T and OE but no account for inventory I; shows that all parameters were not into consideration. Overflow in I could make this initiative such that they were not better off; implementation is therefore inconsistent caused by lack of holistic consideration.

Category; Tool-level / Local level, non-profit, descriptive, inconsistent see the comment.

2. **Hunink MGM. In Search of Tools to Aid Logical Thinking and Communicating about Medical Decision Making. *MEDICAL DECISION MAKING*. 2001;21(4):11.**

Note; Case study, TOC for medical decision making in the radiological unit. Take use of evaporating cloud (EC), current reality tree (CRT)

Comment; Reports that TOC provides an extension of their formal decision analysis. The thinking process (TP) can expand their repertoire in this. Thus, implementation is here

Category; Tool-level / Local level, for-profit, descriptive

3. **Rotstein Z, Wilf-Miron R, Lavi B, et al. Management by constraints: Considering patient volume when adding medical staff to the emergency department. *Isr Med Assoc J*. 2002;4(3):170-173.**

Note; Case study; TOC applied in on non-trauma patients a 24 hour-based emergency department (ED). Identified shortage of physician as an "apparent" constraint. Statistical analysis used to test the hypothesis if added physician reduces the length of stay for patients. Significant results were found in some conditions (in high admission rates).

Comment; T might have been reduced in peak areas. However, the associated OE and I with this initiative is not considered.

Category; Tool-level implementation at ward-scale (local level), non-profit, descriptive

4. **Larson EB. Commentary: Hospital economics of the hospitalist - Twenty-first-century hospitals: Intensification increases. *Health Serv Res*. 2003;38(3):919-922. doi:10.1111/1475-6773.00153**

Note; Review article; Comes with different observations and prediction based on articles and literature from the general healthcare research sphere. With regards to TOC, the paper explains the need for focus on Throughput.

Comment; No of TOC application performed. A good overview of the bigger picture of healthcare transformation.

Category; NA / NA, normative, non-profit

5. **Patwardhan MB, Sarría-santamera A, Matchar DB. Improving the process of developing technical reports for health care decision-makers: Using the Theory of Constraints in the Evidence-Based Practice Centers.** ***International Journal of Technology Assessment in Health Care; Cambridge*****. 2006;22(1):26-32.**

Note; Explorative/Case study; Applies TP-tools for improving report-system that underpin evidence-based practices to policymakers. Reports that TOC has improved the quality of the report system.

Comment; Pure application of TP with no GPM in consideration, thus no imbalance (no inconsistency).

Category; Tool-level application at the local level, descriptive, non-profit

6. **Umble M, Umble EJ. Utilizing buffer management to improve performance in a healthcare environment.** ***European Journal of Operational Research*****. 2006;174(2):1060-1075. doi:10.1016/j.ejor.2005.02.059**

Note; Case study; Implements buffer management in three accident- and ED's (A&E) of three United Kingdom's National Health Service (NHS) hospitals. Reports improvements in different measures (seemingly well-established healthcare measures). Albeit, there is not given an account for how these measures connect with the underlying GPM's of TOC.

Comment; Application of TOC-principles. Inconsistent.

Category; Tool-level application at the local level, descriptive, non-profit

7. **Gupta M, Kline J. Managing a community mental health agency: A Theory of Constraints based framework.** ***Total Quality Management & Business Excellence*****. 2008;19(3):281-294. doi:10.1080/14783360701601850**

Note; Case study; Article reports significant clinical and economic benefits from applying TOC-principles in a mental health center. Solve identified problems based on FFS.

Comment; The authors note that I might been seen as; "patients waiting to be seen or in the process of being served to represent a work-in-process inventory," however it cannot be translated into financial measures. This is due to that we here talk about a for-profit institution, the connection (between I and number waiting for the patient) might very well be more found simpler to establish in a value-based organization where one of the values could be responsivity, quality, etc.

Category; Core-level application at the local level, for-profit, descriptive

8. **Mast J de, Kemper B, Does RJMM, Mandjes M, Bijl Y van der. Process improvement in healthcare: overall resource efficiency. *Quality and Reliability Engineering International*. 2011;27(8):1095-1106. doi:10.1002/qre.1198**

Note; Exploratory study; Attempts on linking several different methodologies to establish a framework to measure performance measures of processes. Use FFS and some TOC-principles to undergird some of the suggestions.

Comment; With regards to this dissertation focus on transforming the core of TOC, this is outside of the scope. The articles conceptualization of patients' trajectory throughout hospital processes seems very fruitful for the end product of the transformed framework of this dissertation. Initiatives are not guided towards an improvement of GPM's.

Category; Tool-level / Local level, non-profit, normative

9. **Mur-Veeman I, Govers M. Buffer management to solve bed-blocking in the Netherlands 2000–2010. Cooperation from an integrated care chain perspective as a key success factor for managing patient flows. *Int J Integr Care*. 2011;11(Special 10th Anniversary Edition). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3180700/. Accessed January 13, 2019.**

Note; Case study; A ten-year case study aimed at the specific problem of "bed-blocking" in the Dutch hospital. The research reports that four out of five negative arguments concerning the use of buffer management in the hospital can be refuted.

Comment; Use TOC-principles and drum-buffer-rope to rationalize initiatives. Initiatives are not guided towards an improvement of GPM's. The articles conceptualization of bed-flow throughout hospital processes seems very fruitful for the end product of the transformed framework of this dissertation; especially the framework of the multi-level strategy for cooperation.

Category; Tool-level / Local level, non-profit, descriptive and partly normative

10. **Schrijvers G, van Hoorn A, Huiskes N. The care pathway: concepts and theories: an introduction. *Int J Integr Care*. 2012;12.**

Note; Explorative study; Examines what operations management methodologies can do to impact the care pathways in the health sector positively. Elucidates that FFS can be used to augment care pathways.

Comment; Initiatives are not guided towards an improvement of GPM's. Reasons that TOC especially might provide the advantage of shortening waiting times.

Category; Tool-level / Local level, non-profit, normative

11. **Kemper B, de Mast J. Measurement Plans for Process Flow Improvement in Services and Health Care. *Quality Engineering*. 2013;25(4):437-450.doi:10.1080/08982112.2013.805779**

Note; Explorative study; Deduce flow parameters based on three operations management methodologies; Lean management, TOC, and Six Sigma.

Comment; Derives some measures from the TOC's GPMs such as, e.g. "Throughput Time." Might be useful for the fruitful for the resulting transformed framework in this dissertation.

Category; Core-level / Local level, non-profit, normative

12. **MacDonald SL, Cowan IA, Floyd R, et al. Measuring and managing radiologist workload: Application of lean and constraint theories and production planning principles to planning radiology services in a major tertiary hospital.** ***Journal of Medical Imaging and Radiation Oncology*****. 2013;57(5):544-550. doi:10.1111/1754-9485.12090**

Note; Case study; Radiologist's workload management to reduce the impact of limited radiologist's practitioner hours (the constraint). Applied TOC-principles among with lean management and production planning principles. Reports significant

Comment; Uses performance measures defined outside TOC. Not clear how the initiatives was directed by reasoning from TOC.

Category; Tool-level / Local level, non-profit, descriptive

13. **Sadat S, Carter MW, Golden B. Theory of constraints for publicly funded health systems.** ***Health Care Management Science; New york*****. 2013;16(1):62-74. doi:http://dx.doi.org/10.1007/s10729-012-9208-9**

Note; Review article, explorative study, Performs a transformation of TOC to the public hospital sector. Article of special interest for this dissertation.

Category; Core-level / Global level, non-profit, normative

14. **Gupta MC, Bridgman S, Kaur Sahi G. Application of TOC-based framework to improve market orientation in a non-profit organization.** ***Journal of Strategic Marketing*****. 2015;23(7):579-599. doi:10.1080/0965254X.2014.1001865**

Note; Case study; TOC applied for the marketing practices of a mental health institution. This article transforms the core of TOC and thus is of special interest towards this dissertation.

Category; Core-level / Global level, non-profit, descriptive and normative

15. **Aguilar-Escobar V-G, Garrido-Vega P, Gonzalez-Zamora M-M. Applying the theory of constraints to the logistics service of medical records of a hospital.** ***EUR RES MANAG BUSECON*****. 2016;22(3):139-146. doi:10.1016/j.iedee.2015.07.001**

Note; Case study; TOC applied on the logistics of the medical records in a hospital. The study reports improvement of customer satisfaction and delivery date compliance.

Comment; Uses FFS and establishes its goal to be "maximize the high-quality medical service provided to customers, at present, and in the future" which is limited by the budget and providing a safe and satisfactory working environment for the workers. Based on this, they choose the three operational measures; customer satisfaction, delivery date compliance, and OE. The initiative's concluding success get underpinned by the alignment of two of the established performance measures; customer satisfaction and delivery date compliance. Firstly, this is in its essence an inconsistent evaluation of the implementation as it should take into account all the performance measures and not only those who get improved; one can then not say if the initiative was an overall improvement. Secondly, there seems to be a problematic arbitrariness of the performance measures that was chosen, which seems not to be argued for.

Category; Core-level / Local level, non-profit, descriptive, inconsistent

16. **Cattaneo C, Bassani G. The TOC Thinking Process: The viability of change. *Hum Syst Manag*. 2016;35(4):301-323. doi:10.3233/HSM-161616**

Note; Exploratory study; Claims to reframe every tool encompassed by TP for the healthcare sector.

Comment; Might be fruitful for the resulting transformed framework in this dissertation as TP is a powerful tool of finding what to change, what to change to, and how to make the change. The article gives a thorough account of the individual tools of TP.

Category; Tool level / Global level, non-profit, normative

17. **Leskela R-L, Herse F, Torkki P, Laine J, Vilkuna T, Raatikainen T. Analysis of the adoption of new health technology: the case of Dupuytren's disease. *Int J Health Technol Manag*. 2016;15(3):210-227. doi:10.1504/IJHTM.2016.078360**

Note; Case study; Study is based on TOC-principles to analyses the stakeholder's incentives for adoption of new technology towards Dupuytren's disease both in the private and public sector.

Comment; Pure constraint-based research. Do not consider performance measures.

Category; Tool level / Local level, non-profit, descriptive

18. **Pawlak R. Theory of Constraints What Can We Learn to Support the Nursing Workforce? *J Nurs Adm*. 2016;46(11):558-560. doi:10.1097/NNA.0000000000000404**

Note; Exploratory study; Looks at how TOC-framework can help conceptualize constraint in the nursing workforce. Suggestion pure based on constraint-based thinking. The study suggests TOC-thinking may provide an insightful conceptualization of the nursing labor workforce.

Category; Tool level / Local level, non-profit, normative

19. **Pergher I, Brandolf VP, Pacheco DA de J, Vaccaro GLR. A patient-centric approach to improve health care services. *Cogent Business & Management*. 2016;3(1):1227232. doi:10.1080/23311975.2016.1227232**

Note; Case study; Study concerns the radiotherapy service authorization in a large Brazilian hospital. The study makes use of principles from Total Quality Management and TOC. From TOC, there is used the tools of CRT and root cause (RC) analysis. The study reported an increased understanding of RC through RC analysis.

Comment; Only TP-tools was used apart from any TOC-measures.

Category; Tool level / Local level, non-profit, descriptive

20. **Rawson JV, Kannan A, Furman M. Use of Process Improvement Tools in Radiology. *Current Problems in Diagnostic Radiology*. 2016;45(2):94-100. doi:10.1067/j.cpradiol.2015.09.004**

Note; Exploratory study; Uses different concepts from different OM-methodologies can improve the management of radiology. Presents and explains how some of the TOC-principles, FFS, and RC analysis can be applied in the radiology.

Comment; The study interestingly juxtaposes T and "Flow"; Obstacles to "Flow" are constraints in the system. This is a contradicting to the notion that every system has one or only a few constraints.

Category; Tool level / Local level, non-profit, normative

21. **Groop J, Ketokivi M, Gupta M, Holmström J. Improving home care: Knowledge creation through engagement and design.** ***Journal of Operations Management*****. 2017;53-56:9-22. doi:10.1016/j.jom.2017.11.001**

Note; Case study; The study applies TOC i.a. OM-methods in the development of the home care system in two cities in Finland. Suggests the use of CRT, evaporation cloud (EC) to deal with undesirable effects (UDEs). Article reports lessons learned by the application of these tools.

Comment; Do not suggest any implementation of performance measures.

Category; Tool level / Global level, non-profit, descriptive

22. **Nestsiarovich A, Hurwitz NG, Nelson SJ, et al. Systemic challenges in bipolar disorder management: A patient-centered approach.** ***Bipolar Disorders*****. 2017;19(8):676-688. doi:10.1111/bdi.12547**

Note; Case study; Study performed on patients and the family members of patients with bipolar disorder. The article reports the revelation of a profound conflict using root cause (RC) analysis from TOCs TP. Also, claim that RC analysis revealed underlying conflict that can be extrapolated to a larger population of patients.

Comment; Pure TP-implementation. No use of performance measures.

Category; Tool level / Local level, non-profit, descriptive

23. **Criddle J, Holt J. Use of Simulation Software in Optimizing PACU Operations and Promoting Evidence-Based Practice Guidelines. *Journal of PeriAnesthesia Nursing*. 2018;33(4):420-425. doi:10.1016/j.jopan.2017.03.004**

Note; Case study; Simulation software gets utilized to optimize post-anesthesia care unit (PACU). TOC is applied in the sense that it justifies PACU is the constraint of the institution.

Comment; The definition of constraint is the only concept brought from TOC. The connection to TOC is rather low.

Category; Tool level / Local level, non-profit, descriptive

24. **Fung-Kee-Fung M, Maziak DE, Pantarotto JR, et al. Regional process redesign of lung cancer care: a learning health system pilot project. *Curr Oncol*. 2018;25(1):59-66. doi:10.3747/co.25.3719**

Note; Case study; Redesign of the lung cancer patients' journey from diagnosis to initiation of treatment. Article reports improvement amounting to a decrease in median patient waiting time from 47 to 92 days.

Comment; Article does not provide documentation of which specific parts of TOC that was in use.

Category; NA / NA, non-profit, descriptive

25. **Huang W-T, Chen P-S, Liu JJ, Chen Y-R, Chen Y-H. Dynamic configuration scheduling problem for stochastic medical resources. *Journal of Biomedical Informatics*. 2018;80:96-105. doi:10.1016/j.jbi.2018.03.005**

Note; Case study; Redesign of a scheduling system for surgical rooms in Taiwan.

Comment; Utilizes DBR to manage the scarce resource of anesthesiologists with highly stochastic demand. One of the firmest and extensive statistical analysis on buffer management among the articles. No documentation of TOC-measurement improvement nor the outcomes relation to them documented.

Category; Tool level / Local level, non-profit, descriptive and normative

26. **Mabin V, Yee J, Babington S, Caldwell V, Moore R. Using the Theory of Constraints to resolve long-standing resource and service issues in a large public hospital. *Health Systems*. 2018;7(3):230-249. doi:10.1080/20476965.2017.1403674**

Note; Case study; Implementation of TOC-concepts in a large public hospital in New Zeeland. The study reports that the initiative resulted in a "dramatic" improvement of wait times, patient satisfaction, number overtime hours, etc.

Comment; Utilizes the thinking process. No documentation of TOC-measurement improvement nor the outcomes relation to them documented.

Category; Tool level / Local level, non-profit, descriptive

27. **van Harten WH, Goedbloed N, Boekhout AH, Heintzbergen S. Implementing large scale fast track diagnostics in a comprehensive cancer center, pre- and post-measurement data. *BMC Health Services Research*. 2018;18(1):85. doi:10.1186/s12913-018-2868-5**

Note; Case study; The study reports that the redesign and implementation of fast track diagnosis for 18 cancer types. The initiative reduced throughput time and "access time" considerably.

Comment; TOC-principles was used to reveal bottleneck in the diagnosis process. Uses derived the TOC-measure throughput time.

Category; Tool level / Local level, non-profit, descriptive

Scopus databases

1. Schaefers J, Colin J, Aggoune R, Kucina M. A contribution to performance measurement in the healthcare industry: The industrial point of view. *International Journal of Business Performance Management*. 2007;9(2):226-239. doi:10.1504/IJBPM.2007.011864

Note; Review article, explorative study; Promotes a transformation of TOC to the public hospital sector. Article of special interest for this dissertation.

Category; Core-level / Global level, non-profit, normative

2. Wu F, Jia T, Liu SL, Qi JY. The analysis of service station allocation in the hospital based on the bottleneck model. *International Journal of Services, Technology, and Management.* 2009;12(2):231-251. doi:10.1504/IJSTM.2009.025236

Note; Conceptual study; Tentatively develops a mathematical analytic method for locating bottlenecks in a Chinese Hospital.

Category; Tool level / Global level, non-profit, Normative and descriptive

3. Stratton R, Knight A. Managing patient flow using time buffers. *Journal of Manufacturing Technology Management.* 2010;21(4):484-498. doi:10.1108/17410381011046599

Note; Case study; Study of past case studies in the pursuit to find how and why past implementations made improvements in hospitals of NHS.

Comment; No documentation of TOC-measurement improvement nor the outcomes relation to them documented.

Category; Tool level / Global level, non-profit, descriptive

4. Laureani A, Brady M, Antony J. Applications of Lean Six Sigma in an Irish hospital. *Leadership in Health Services.* 2013;26(4):322-337. doi:10.1108/LHS-01-2012-0002

Note; TOC-concepts is a peripheral matter in this study.

Category; NA / NA

5. Sahraoui A, Elarref M. Bed crisis and elective surgery late cancellations: An approach using the theory of constraints. *Qatar Medical Journal.* 2014;2014(1). doi:10.5339/qmj.2014.1

Note; Case study; Study performed in hospitals in the middle east on lowering the cancellation rate on elective procedures. The study reports the identification of a "workable and effective" way of reducing the cancellation rate by using FFS

Comment; FFS used. No TOC-performance measures used.

Category; Tool level / Local level, non-profit, descriptive

6. Verma A, Lee MY, Wang C, Hussein NBM, Selvi K, Tee A. Efficiency of performing pulmonary procedures in a shared endoscopy unit: Procedure time, turnaround time, delays, and procedure waiting time. ***Journal of Bronchology and Interventional Pulmonology*****. 2014;21(2):135-141. doi:10.1097/LBR.0000000000000050**

Note; Explorative study; Based on TOC-principles, the study suggests how to optimize the room scheduling for pulmonary operations.

Comment; TOC-principles suggested. No TOC-performance measures in consideration.

Category; Tool level / Local level, non-profit, normative

7. de Souza MC, Souza TA, Vaccaro GLR. Hospital bed management: An analysis from the perspective of the theory of constraints. ***Espacios*****. 2016;37(30).**

Note; Exploratory Case Study; TOC-used in the management of bed in a Brazilian Hospitals. Use of FFS and TP to localize problems

Comment; No TOC-performance measures in consideration.

Category; Tool level / Local level, non-profit, normative and descriptive

PubMed databases:

1. Roybal H, Baxendale SJ, Gupta M. Using activity-based costing and theory of constraints to guide continuous improvement in managed care. ***Managed Care Quarterly; Frederick*****. 1999;7(1):1-10.**

Note; Exploratory study; Applied FFS and reported to have developed an activity-based financial model for use in mental and substance abuse facility

Comment; No TOC-performance measures in consideration.

Category; Tool level / Local level, non-profit, normative

2. Trickey H, Newburn M. Goals, dilemmas, and assumptions in infant feeding education and support. Applying the theory of constraints thinking tools to develop new priorities for action. *Maternal & Child Nutrition*. 2014;10(1):72-91. doi:10.1111/j.1740-8709.2012.00417.x

Note; Utilizes TP for education and support of infant feeding.

Comment; No TOC-performance measures in consideration.

Category; Tool level / Local level, non-profit, normative

Other sources

"Other" includes Research Gate and Google Scholar, and plain Google-search was used in addition, as they are hit-and-miss in, they get collected an additional.

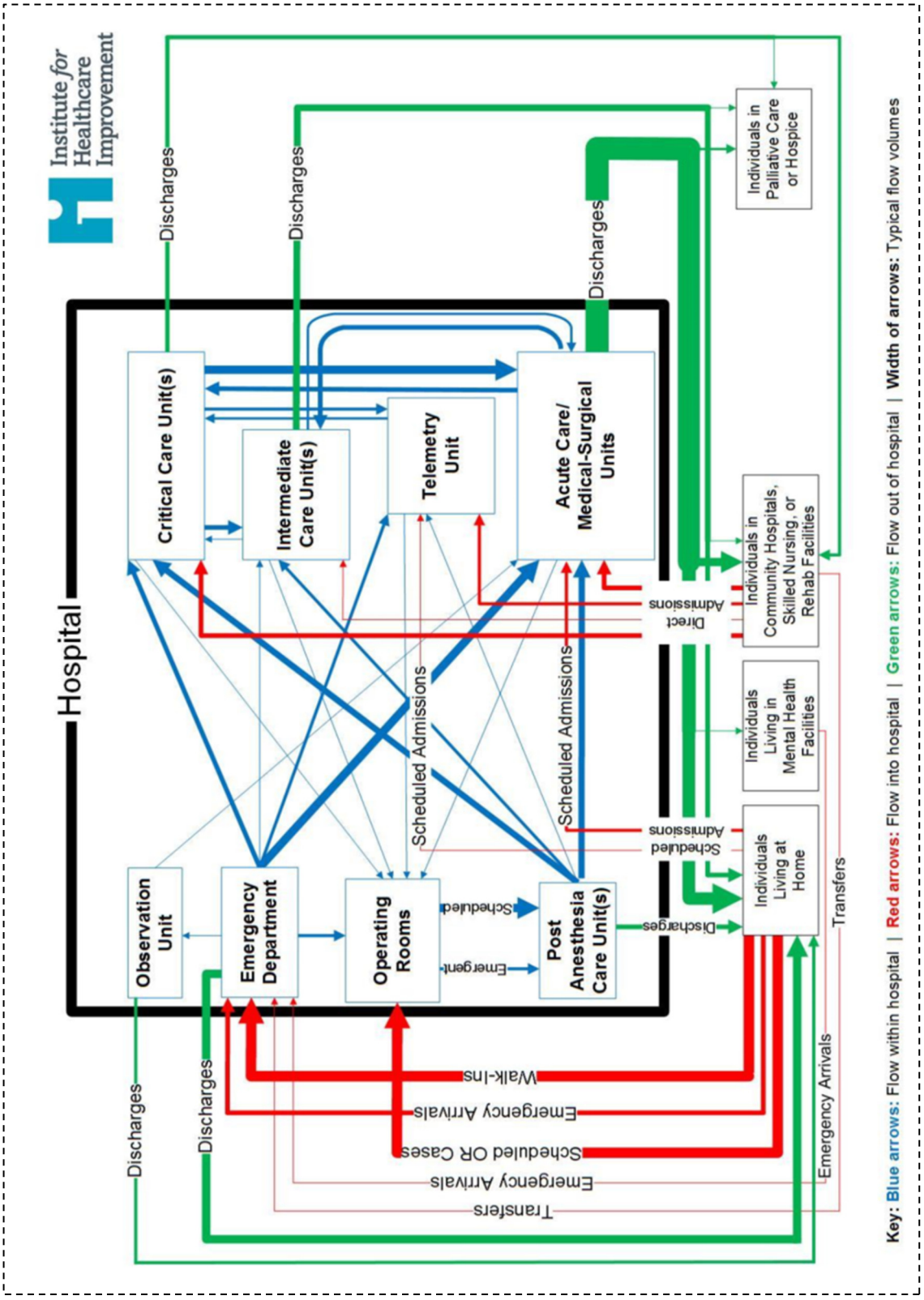
1. Tomolo A, Burton-Houle T, Aron D. Applying the Theory of Constraints in Health Care: Part 1—The Philosophy. *Quality management in health care*. 2002;10:40-46. doi:10.1097/00019514-200210030-00010

Note; Review article, explorative study, Suggestions to the transformation of TOC to the public hospital sector. Article of special interest for this dissertation.

Category; Core-level / Global level, non-profit, normative

A.3 – Miscellaneous Exhibit

Miscellaneous figures in this dissertation



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