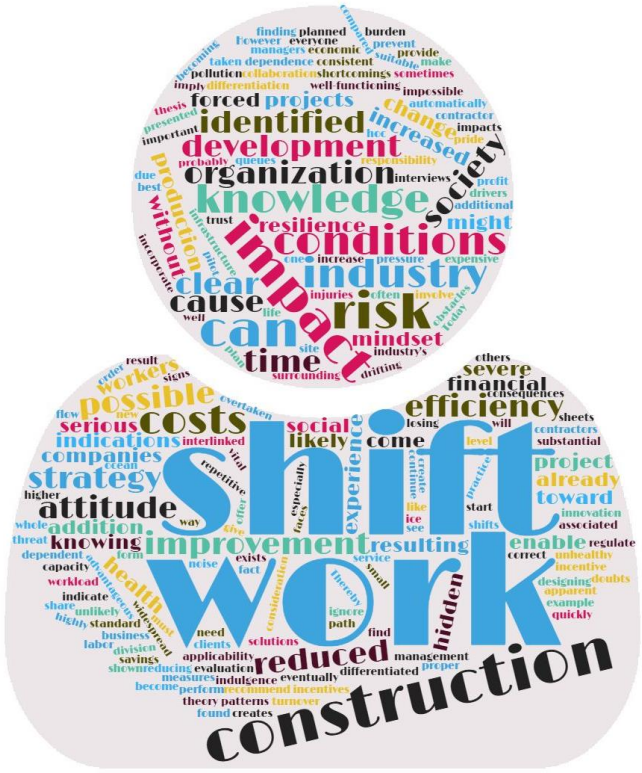

Key Conditions That Permit Shift Work in the Construction Industry

Economic & Social Effects Related to Shift Work
Master's thesis in the Master`s Programme Design and Construction Project Management

EMMA ELIASSON
OSCAR MÖLLER

MASTER'S THESIS ACEX30-18-18

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Department of Architecture and Civil Engineering
Division of Construction Management
Chalmers University of Technology
SE-412 96 Göteborg
Sweden
Telephone: + 46 (0)31-772 1000

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ABSTRACT

Compared to other production industries, shift work has never been introduced on a large scale in the construction industry which is partly caused by the restriction of noise generating activities in urban areas, but also by the complex multi-company structure construction project consist of which obstructs and complicate the innovation process. With increasing production cost and significant impact on the society, environmentally and resource consuming, new and efficient production strategies are urgent. This thesis questions whether economic incentives can be identified by applying shift work in a construction project, where the preconditions are not considered well suited by the industry. This is done through conducting an economic evaluation and apply shift work on a standard Road and Sewer project and theoretically calculate the impact shift work would entail. Besides, a comprehensive empirical study though selective interviews were conducted to identify the view of shift work today, what challenges the industry faces and barriers for implementing shift work as a competitive strategy.

The financial evaluation indicated that by applying shift, it is possible to increase revenues up to 26 percent. It also showed there are significant variations in profitability between the shift structures, and it is therefore of great importance to understand the preconditions and how they are affected by shift work in order to choose the most suitable shift structure. It was evident in the empirical finding that shift work requires a significantly higher level of planning, coordination, and cooperation from all involved parties of the project. Another outcome was that there is an underlying resistance toward innovation and finding new solutions, which is likely to prevent development. This attitude and mindset is probably the most substantial obstacle the construction industry faces to experience an improvement in efficiency. A company must be willing to go through a change to sustain their market position and survive in an increasingly fearsome competition, which puts higher demand on the contractor.

Keywords: *Shift work, Health impact, Diseases connected to shift work, Circadian rhythms, Effects of shift work, Evening work, Work hours, Safety, Social patterns, and Construction sector.*

Förutsättningar som möjliggör Skiftarbete i Byggindustrin

Ekonomisk & sociala effekter relaterade till skiftarbete

Examensarbete inom mastersprogrammet Organisation och Ledning i Bygg- och Fastighetssektorn

EMMA ELIASSON
OSCAR MÖLLER
Institutionen för arkitektur och samhällsbyggnadsteknik
Avdelningen för Construction Management
Chalmers tekniska högskola

SAMMANFATTNING

I jämförelse med andra tillverkningsindustrier har skiftarbete aldrig introducerats på stor skala i byggbranschen, vilket delvis beror på de ljudbegränsande lagar branschen måste anpassa sig efter men även att det finns en komplex företagsstruktur i byggorganisationer vilket försvårar möjligheten till innovation och förändring. Då kostnaden för byggprojekt eskalerar och en stor påverkan på samhället, miljön och resursförbrukningen, är det tydligt att sökandet efter nya produktionsstrategier är av yttersta vikt. Denna masteruppsats utreder huruvida det finns ekonomisk vinning i införande av skiftarbete i väg och anläggningsprojekt, vilka har låg komplexitet och är vanligt förekommande projekt, samt där förutsättningarna idag inte anses som troligt gynnsamma för skiftarbete. Detta sker genom att teoretiskt applicera skiftarbete i ett väg- och anläggningsprojekt och beräkna den uppskattade ekonomiska förändring skiftarbete skulle medföra. Ytterligare utfördes en empirisk undersökning genom selektiva intervjuer utav ett spektrum av positioner i byggbranschen för att få en heltäckande bild av hur synen på skiftarbete är idag, vilka utmaningar branschen står inför och identifiera hinder mot att använda skiftarbete som en företagsstrategi.

Den ekonomiska beräkningen visar på att genom att introducera ett andra skift är det möjligt att öka avkastningen med upp till 26 procent. Beräkningen visade även på tydliga skillnader i lönsamhet mellan skiften, samt att förstå vad som driver kostnader och hur projektförutsättningarna för att därmed kunna välja den lämpligaste skifttypen. Det var tydligt i den empiriska undersökningen att skiftarbete kräver markant högre planering, koordinering och samarbete av alla involverade parter. Empiriska undersökningen visade även på att det finns ett underliggande motstånd mot utveckling och innovation. Denna inställning är troligtvis det största hinder branschen måste övervinna innan en branschutveckling kommer ske. Ett företag måste kunna gå igenom en förändring och förnya sig för att behålla sin marknadsposition när konkurrensen på marknaden blir allt tuffare, vilket i slutändan sätter allt högre krav på entreprenörer.

Nyckelord: *Skiftarbete, Hälsoeffekter, Sjukdomar kopplade till skiftarbete, Dygnsrytm, resultat av skiftarbete, Kvällsarbete, Arbetstid, Säkerhet, Sociala mönster, Byggbranschen.*

Contents

Preface

This master's thesis is the closure of our Master of Science in Civil Engineering education at Chalmers University of Technology in Gothenburg. We would like to extend our gratitude to everyone that took their time, and through interviews, meetings and coaching provided support which enabled us to complete this thesis and contribute with new research in the area of production efficiency in the construction industry. Our special gratitude goes to our supervisor Rikard Sandberg, PhD Student at Architecture and Civil Engineering at Chalmers University of Technology, who has continuously throughout the process been an excellent support and the collaboration with the authors were wonderful. Further, would we like to appreciate our examiner at Chalmers, Christine Räisänen, who provided information and support during the process.

We would also like to address our special gratitude to our supervisor at the construction company, Björn Krook. Björn´s experience and commitment enabled us to identify the most vital research questions and helped us find interviewees who could contribute with insight of the production process.

Emma Eliasson and Oscar Möller

June 2018
Gothenburg

1. Introduction

Shift work is a well-established method to extend the working hours per day, used all over the world (Lee, McCann, & Messenger, 2007). According to Lee, McCann, & Messenger (2007), shift work is mainly concentrated to the manufacturing and service sector and has not been introduced on a large scale in the construction industry. In many industries, shift work is used to reduce fixed costs of the operation, and to meet rising demands for productivity and efficiency (Folkard & Tucker, 2003). This endeavor for increased production has led to the fact that one in five workers in Europe works in shift (Harrington, 2001). The construction industry has appointed itself and has been appointed by external parties, to be a conservative industry which may be a contributing factor to why shift work has not even been investigated for the construction (Clausén & Sjödin, 2008).

Pointed out as one of the essential reasons to why the construction industry has not considered shift work to be appropriate is because there is a high degree of uncertainty in the industry, where it is difficult to predict events during the execution (Clausén & Sjödin, 2008). It is also believed that the industry consists of many different actors who are involved in a project, which complicates large changes, like introducing shift work. Also, the construction industry has a significant impact on the surrounding society through causing traffic congestion, affecting local business and cause noise and pollution generating activities (Gilchrist & Allouche, 2005). The noise generating activities are controlled by the noise regulations which may prevent projects from performing work more than eight hours per day, which is pointed out as one of the main obstacles for the construction industry ((Naturvårdsverket, 2004); (Clausén & Sjödin, 2008)). Another reason to why no significant change is happening in the industry is because the competition in the industry is fearsome, and with low entry barriers, companies must continuously focus to reduce their cost or try to differentiate from competition to maintain a strategic advantage (Grant, 2016). According to (Hanna, Chang, Sullivan, & Lackney, 2008), contractors usually have a profit margin of 2 to 3 percent of the total project budget. This leaves no room for additional costs to the project and therefore comes new working routines with a high risk but nonetheless could entail high reward if succeeding.

However, Hanna et al. (2008) state that shift work can reduce the project duration and in some cases have a positive increase in the productivity of the project. Further, Hanna et al. (2008) mean that the manufacturing industry has chosen to work in shift, which is not a demand from the society. Instead, it is mainly due to the economic benefits where the industry has created conditions, with standardization of activities and work moments (Lee et al., 2007). For the same reason, the potential economic advantages of the construction industry should be further investigated, which is research that previously has not been made to a greater extent. If it is possible to demonstrate that there are financial incentives when applying shift work, it can act as an eye opener for companies to explore pros and cons with shift work more deeply. There is currently insufficient research to ensure that shift work in the construction industry is not an advantageous alternative, which this thesis intends to handle.

Corporations' objective to increase their profitability is sometimes accomplished by implementing shift work to their strategy, which can affect the workers' health. According to Li and Poon (2013;2014) shift work causes an increased risk of

workplace accidents through fatigue, achievement pressure and a continuous change in the process. This is of high relevance and must be taken into consideration when evaluating whether or not shift work is a suitable strategy for the construction.

For the construction industry, there are four underlying factors to why shift work sometimes is forced into a project, and these are mandated acceleration, performance delay, external factors and change orders (Hanna et al., 2008). It is then likely that the working environment is unplanned which can result in lack of safety, poor coordination between shifts and substantially reduced productivity. If the shift work instead could be carried out under more planned and controlled conditions, the circumstances for both the workers who perform the job and for the society around could be considerably better and should be of the company´s interest ((Costa, 2003a); (Gilchrist & Allouche, 2005)).

1.1 Purpose and Project Aim

The purpose of this master thesis is to study the conditions and impacts of an implementation of shift work in a construction project and what consequences it would entail. Then, based on the acquired knowledge, create a model were essential criteria which enable a successful project with shift work are compiled. By using this model, the preconditions of a project can be evaluated to determine whether or not conditions are beneficial to use shift work as a strategy.

1.2 Problem Statement

The objective of the thesis is to identify the conditions required to implement shift work and what the effect of shift work should mean for the industry. In order to evaluate the suitability of shift work, for each project, an evaluation model has been accomplished, describing preconditions required for apply shift work in construction projects. Also, identify if there are barriers in the company that requires attention to enable implementation of shift work. The primary areas that will be evaluated are:

- *Economical*
    - Are there economic advantages to gain from shift work?
    - Identify the most profitable shift structure for the selected project.
- *Time*
    - What are the possibilities when it comes to shortening the time plan by implementing shift work and what risks and opportunities are associated with this?
    - Who can benefit from reducing the construction time of the project?
- *Social*
    - In what way will shift work affect the workload of the employees?
    - How will the surrounding society be affected by shift work implementation?
    - What are the obstacles regarding work regulation?
    - How does shift work affect stress and safety at the constructions site?

1.3 Method

The study was conducted by using an abductive approach, where first a theoretical framework was made followed by a case study including calculations, which represent the quantitative part of the thesis.

The thesis is based on a theoretical framework with a focus on academic papers that address resource utilization, consequences from shift work and management in the construction industry. To identify whether or not shift work could entail financial advantages, a case study was conducted in collaboration with a construction company to study what effects a second shift would entail. The theoretical framework was used to design the shift work, the number of crews, working hours and size of the site management, in accordance with health ergonomic recommendations. In the study, a representative project was chosen, within the selected infrastructure department of the company, to analyze how the project is affected when one more shift is added to the project. To strengthen the results of the economic evaluation, and add the dimensions of experience and understanding, selective interviews have been conducted with vital members within the organization and with different roles of the production organization, support functions to the organization, subcontractor, and client to the organization.

1.4 Delimitations

The financial calculation is limited to four shift structures with two variations in overlap, which are further presented in the financial evaluation. The authors have selected these shift structures in consideration to ergonomic recommendations presented in chapter 3.2 and 3.4 to limit the health impact. The financial evaluation focuses on one selected project, which is representative for the infrastructure department in Gothenburg in term of construction time, budget, organization, number of subcontractors and work activities. By constrain the evaluation to one project, the results credibility of repetition in future project reduces but can be seen as an indication whether deeper analyze can be of interest. The financial evaluation will not take into consideration how shift work would affect the surrounding society financially.

Further, this thesis will not handle what type of contract that is used between the client and the contractor or if shift work is more suitable to any particular contract form. Neither will evaluation if the contractor's office functions, such as HR, need to expand to support shift work. Moreover, will not the risk of reducing, or the possibility to improve, the quality of the finished product through shift work be addressed in this thesis.

2. Methodology

The following chapters present information about how the research has been collected and the reasons for choosing these methods. The study was conducted by using an abductive approach, where first a literature study was made followed by a case study including calculations, which represent the quantitative part of the thesis. What should be clarified is that the primary focus lies in the qualitative study, with empirical findings which are utilized in line with the abductive approach. Further, the analysis of the data is a continuously ongoing process throughout the qualitative study.

2.1 Research Approach

When choosing the research approach, a selection between deductive, inductive and abductive approach was made (Mirza, Akhtar-Danesh, Noesgaard, Martin, & Staples, 2014). According to Mirza et al. (2014), a deductive approach is primarily concerned with developing hypotheses from existing theory and developing a research design to test the hypotheses. An inductive approach, on the other hand, will provide a limited conclusion that is based on restricted information and observations. Thereby the conclusion will be based on the observed fact, which hardly makes it entirely correct due to the limitations in the research of the inductive approach. The inductive approach takes the specified and limited observations and creates a general conclusion, through identifying patterns. This result in that the inductive arguments cannot be cogent. However, unlike the deductive approach, the inductive approach can increase the "human knowledge". The last approach is the abductive approach which starts with an incomplete set of observations to find the most possible explanation, by the means of the gathering observations ((Walton, 2004; 2005); Mirza et al., 2014)). The abductive approach is taking advantages of the interactions between theoretical and empirical findings and where the findings are highly affected by the researchers' approach and will influence the alternated interaction in the analysis. Even the abductive approach has a lack of completeness where some observations could be missed depending on the researchers, like the inductive approach (O'Hearn, 2010). The founded observations are used to create a conclusion that matches the information that is available. The abductive approach makes it possible to work more toward an innovative solution through, in some ways, a combination between a deductive and an inductive approach.

The research approach used was an abductive approach, which involved finding the conclusion through an iterative process where the theory influences the usage of the empirical study, and analysis influence further collection of additional theory (Alvesson & Sköldberg, 2009). In accordance with Dubois and Gadde (2002), insight from both empirical and theoretical data was utilized through an elaboration. The theoretical framework facilitated to give an initial direction for the empirical study and to further elaborate on similarities and difficulties between the research approaches by interactions between the theories and empirics. Knowledge about the subject could either be explored in the literature study, or in the empirical study which together gave a new view of shift work and how it is problematized. Through a combination between theory, case studies and empirical findings the thesis has been accomplished which is a part that Dubois and Gadde (2002) highlighted as important.

2.2 Literature Review

The literature framework was the initial foundation of the thesis, from which the aim was to get a more in-depth understanding, serve as preparation of the empirical findings and the financial evaluation (Bryman & Bell, 2003). The information was collected through chosen sub-areas connected to shift work and the consequences of shift work considered relevant for the thesis. The sub-areas discussed in the literature study are based on areas highlighted by interviewees. Therefore, during the process, sub-areas have been added and removed depending on the relevance according to the empirical study.

The thesis consists of a quantitative sub-study where a construction project was evaluated, followed by how the project is affected economically and temporally by shift work. Finally, an evaluation of shift work through an empirical study was conducted, which formed the qualitative part of the thesis. This means that both a quantitative and a qualitative study was conducted. However, the thesis primary focus was on the qualitative study where the consequences and opportunities of shift work were identified. This framework and research parts created together conditions for discussion, analysis, and the conclusion. The theoretical framework was used to reach observations and findings, in line with thoughts of Bryman and Bell (2003).

The literature has been designed to build up explanatory statements to later in the analytical part of the thesis be able to question the current view of shift work in the construction sector. The literature also highlighted some tangible and substantial obstacles to why shift work is hard to implement in the construction industry and what consequences shift work brings. The prime search engine used for collecting literature was SUMMON at Chalmers' library, but also by Google Scholar and further through reference lists of relevant articles. Every reference was criticized and reviewed before being used, through a simpler evaluation of the publisher and that the publisher is of a respected institution, including the relevance of the publication year for the reference. There was also of importance to find independent literature that has not been colored to anyone's advantages. The primary keywords used for the literature review were; *shift work, health impact, diseases connected to shift work, circadian rhythms, outcomes of shift work, evening work, work hours, safety, social patterns, and construction sector.*

2.3 Case Study

The case study was made in collaboration with the infrastructure department of a large construction company in Sweden. A representative project has been chosen within the infrastructure department to analyze how the project is changing when one more shift is added to the project. The chosen project was considered a standard project for the department regarding budget, time and resource intensive, in other words, a project with preconditions that can be found in upcoming projects. In addition to this selected project, interviews with persons within the company have taken place to gain an understanding of how and when shift work is performed in practice.

Inputs from external parties were restricted to one subcontractor, and one client in regards to the thesis was conducted in collaboration with one Construction Company, where the primary focus lied. To reach a brief understanding of the external obstacles

and what a change toward more shift work would mean for the industry, interviews with in-house persons of the organization was also asked to display their thought about the external obstacles in the sector. This to point out and map the present situation of the organization and to see what obstacles are internal and external and the in the characteristics of the department, according to the organization and the literature. All information was compiled to find connections between projects where shift work is functioning and projects where there is a possible potential and when it is not, which has been investigated in this thesis by gaining experience through a qualitative design (Bryman & Bell, 2003).

2.4 Interviews

In addition to the literature and the financial evaluation of a chosen project, interviews were conducted to get a more in-depth insight and understanding of the organization, also to emphasize the problems and obstacles that are visible in-house. As a compliment to the previous research in the subject shift work and to find a deeper connection and a link to the construction industry an empirical approach has been conducted.

It was of importance to receive a detailed understanding of how the employees of the construction site viewed shift work, what barriers and challenges they viewed as most vital that shift work might entail. To ensure a broad understanding, interviews were conducted with both members of the on-site production team and members of the support functions available in the company. Through interviews with both senior and junior employees parallel with experience from individuals of different levels and departments of the organization, an analysis was performed of the current situation of the organization as well as challenges and possibilities that the industry faces were identified.

Kvale (1996) has come up with stages of how to conduct an interview in qualitative research. The first stage deals with the purpose of the interview, what should be investigated and how it should be accomplished. By basing the interview questions on the thesis research questions, Kvale's first stage was completed. The next phase, called the design phase, involves interview structure, lengths of interviews and number of questions. Semi-structured interview method was chosen, which combines predefined questions with unrestricted elaboration (Wilson, 2014; 2013). According to Wilson (2014; 2013), this method is suitable when the interviewer already has knowledge about the research subject but in search of further information. Furthermore, using semi-structured method enables both open-ended and closed-ended questions which can supply both quantitative and qualitative data (DiCicco-Bloom & Crabtree, 2006). It is also more suitable than a structured interview method when the questions are complex and clarification of the answers might be required. All interviews had the starting point in impacts caused by shift work but were adopted to each interviewee, redesigned based on their competence and expert area. All questions were formed using neutral prompts, to avoid influencing the interviewees with thoughts and values. Before the interviews were conducted, a memo containing general information on the subject of the thesis and research area was sent to the interviewees.

The third stage presented by Kvale (1996) involves the interviewing and setup of the interviews. Before interviews were held, the importance of not enter values and bias into the interviews was discussed, to not affect the answers of the interviewees. The following steps transcription, analyzing, verifying and reporting was done through Kvale's model, where the interviews were transcripted and the information from all interviews was gathered to report the information throughout the thesis.

The interviews were either held on construction site, with the persons working on-site or at the office. Both in-person meetings and meeting over Skype were held, with the average length of the interviews variating between 30 minutes to 1 hour. The selection of persons to interview has been based founding a spectrum of experience in the organization. No random selection has taken place, instead, people at different levels in the organization have been chosen to get a comprehensive view of shift work and its pros and cons. In chapter 5 a list with the roles of the interviewed persons is presented.

2.5 Analysis of Data

Data analysis occurs concurrently through the process in a qualitative study (DiCicco-Bloom & Crabtree, 2006). In agreement with DiCicco-Bloom and Crabtree's (2006) view, analyzes took place throughout the process, in line with an abductive approach, and the work was crystallized dependent on information collected. The abductive approach gives an ability to find patterns to be able to structure the collected information (Alvesson & Sköldberg, 2009). This gave a more reflective approach where reflection and redirections have been taken place during the whole process of the master thesis. The empirical findings have brought a way of thinking where individual thoughts are put against the theories to evaluate the reality in the industry of the theory. Thereby the abduction is a reiterative process, going back and forth and where the researcher's reflections strongly influence research findings. Therefore, it brought high demands of critically look at the result, as it depends on the choices made during the process.

The primary knowledge was gained during the empirical part of the master thesis, while the theoretical part mainly gained inspiration and directions for the thesis. After completing both the literature and interview study, all information was evaluated and results were processed before information was applied in the model of criteria for implementation or not. The model has limitations, which were finally criticized and questioned in the discussion and conclusion.

2.6 Ethic Perspective

To ensure the validity of the thesis, it is essential to act ethically correct to gain maximal outcome of the interviews and their experience within the industry. Thereby it was of importance that the interviewees did not feel harm to participate and join the interview voluntary (Bryman & Bell, 2003). Before each interview started, the interviewees were ensured anonymity in their opinions and how information was handled and presented in the report. Interviewees were informed that the information would be presented anonymously, in accordance with both Bryman and Bell (2003) and DiCicco-Bloom and Crabtree (2006). The confidentiality was guaranteed by neither presenting the name of the company or the name of the interviewees' in the thesis and only mention the interviewees' roles in the company. Sensitive data that

could be connected to a specific person has not been presented in the thesis, to ensure the confidentiality.

Kvale (1996) also mentions that the purpose and method of the interviews and the overall thesis is useful to present for the interviewees to increase their understanding of why the interviews took place. By clarifying the purpose with the interview, what it should be used for as well as what it not should be used to, an understanding and hopefully a more clear view of the purpose of the master thesis could be presented. The interviews were conducted with digital audio tape recording in combination with notes with the purpose to guarantee that not anything could be missed during the interviews and prevent later difficulties. Due to ethical reasons, audio recording was only used after the interviewee had granted permission.

3. Theoretical Framework

This framework has been developed to contribute with insights from previous research about shift work in combination with industry-specific rules and regulations of the construction. How to design shifts, the effects shift work has on efficiency and how the individual as well as the society can be affected of an implementation of shift work, in the construction industry, will further be explained in in this chapter.

3.1 Competitive Advantage

The construction industry is a highly competitive industry (Ball, Farshchi, & Grilli, 2000). By optimizing a company's resource utilization, a significant increase in revenue and reduction of construction time could be achieved, especially for repetitive construction projects such as highways, high-rise buildings, and housing projects (El-Rayes & Moselhi, 2001). When the competition in an industry is fearsome, it is vital for a company to gain a competitive advantage to survive (Grant, 2016). According to Kim and Mauborgne (2005), a company can choose to use a blue or a red ocean strategy. In the blue ocean strategy, demand is created rather than fought over, while in red ocean strategy, companies compete over the existing market demands. Further, Kim and Mauborgne (2005) argue that a blue ocean strategy is created when a company's activities affect both their cost structure and the value proposition to customers. Grant (2016) argues that competitive advantage might not always be revealed as higher profitability, a company can trade current profit in favor of increased market share, technology or customer loyalty, which can favor the company in the long term. Nonetheless, the traditional primary base in competitive advantage comes through an economic advantage in one of two ways, cost advantage or differentiation advantage. Differentiation advantage comes when a company supplies the customer with a product that is differentiated in such a way that the customer is willing to pay a premium price for it, separating the company from its competitors. Projects that are delivered on time and budget are usually highly ranked in key performance indicators (Toor & Ogunlana, 2010). Using shift work to reduce construction time or in phases with high fixed costs is one strategy to ensure on time or budget delivery of a project, and thereby offer the client a superior service.

Contrary to differentiation advantage, cost advantage is a strategy used when a company supplies an identical product or service as their competitors, but to a lower cost (Grant, 2016). Some of the drivers of cost advantages are:

> *Economies of Scale* - By producing large quantities, the fixed cost related to the production reduces per produced item. Industries with high entry barriers through capital-intensive requirement for new entrants are especially subject to economies of scale.
>
> *Economies of Learning* - When knowledge is a scarce resource, learning become a vital process. Examples are workers that learn to perform their job more efficiently, with less wastes and defects, faster production process and improved organizational routines. El-Rays and Moselhi (2001) state that maintaining employees continuity leads to maximizing the learning curve effect and minimizing the idle time of each crew.

Production Techniques - By process innovation and re-engineering of the business process, new techniques can be acquired which can give an advantage over competitors.

Product Design - Through standardization of design, components and production method, efficiency synergies in the production can be achieved.

Input cost - Bargaining power is a tool to negotiate prices and discounts, which can be a significant source for controlling the input cost, especially for large industry-leading companies.

Capacity Utilization - The ratio of fixed to variable cost of a company and the capacity of adjustment from fast to flexible cost. El-Rays and Moselhi (2001) emphasize it is essential to ensure that the phases and work moment with high fixed cost is carefully planned so delays do not extend the time of these phases.

3.2 The Structure of Forming a Shift

There are thousands of shift systems used over the world with considerable differences and adapted to each organization's aspects and preconditions (Costa, 2003a). The primary purpose with shift work is to maximize the use of costly equipment by cover more hours per day, by using several working crews and extending the working day up to twenty-four hours per day instead of the standard eight hours (Folkard & Tucker, 2003). Knauth (1996) argues that there is no "best shift system" suitable for all organizations and industries, so it is unambiguously up to each organization to identify what shift structure that is most suitable for their organization and activities. To successfully implement shift work, it requires high effort in management and involves workers during the design and implementation phase. When designing the structure of shift work, four fundamental areas need to be considered; People, Time, Basic Structure, and Interactions (Miller, 2006).

People

When designing a shift structure, the number of crews must be considered, which is related to the length of the shift, working days and the industry the company operates in (Miller, 2006). In addition, employee turnover and employment ratio are areas which require further attention when implementing shift work and failing to assess these areas are, according to (Miller, 2006), the most common cause of problems related to shift work.

Serious health issues can be connected to shift work, but according to Knauth (1996), these effects can be reduced by designing the shift systems according to ergonomic recommendations. In Sweden, Arbetsmiljöverket in addition to the European Union situates laws regulating maximum of consecutive working hours and minimum resting periods ((Arbetsmiljöverket, 2016) & (Council of the European Union, 2003)). Representatives from the Swedish Construction Federation and The Swedish Building Workers Union negotiate collective agreements for the industry.

Time

The structure of shift work can either be fixed or rotating (Miller, 2006). In a fixed shift system, the crews always work the same type of shift, day, evening or night. According to Miller (2006), one clear advantage with fixed shifts is that employees do not need to readjust their routines when changing shift, which is good from a health perspective. According to Åkerstedt (2003) rotating shift structure can cause a disturbance in sleep rhythm which can have an impact on the health. When rotating shifts are used, the rotation time can be either fast or slow and must be adapted depending on the circumstances (Knauth, 1996). Fast rotation changes shift within a week or daily, slow rotation alternates shift between weeks or even more seldom. A slow rotation would give the worker more time to adjust and thereby reduce the impact of disturbance in circadian rhythm (Åkerstedt, 2003). It is also essential when forming shifts that an overlap between the shifts is considered. Overlap is the time before and after shifts when the crews meet, share information, and control is transferred (Miller, 2006). The length of the overlap will depend on what shift structure that is used and the complexity of the task they perform.

The lengths of a shift could generally be anything between six hours up to twelve hours (Costa, 2003a). Research has shown that there are substantial differences concerning efficiency, job satisfaction, and injury rates, related to the length of the shift, where the risk of injuries increases with the length of the shift (Folkard & Tucker, 2003). Working longer shifts will however provide more continuous days off work, and workers gain social interaction by spending time with family and friends, which increases job satisfaction. Further, there are fewer overlaps between crews, which reduces communication errors and entail high efficiency. Nonetheless, according to Miller (2006), long shifts are not appropriate when the company engages in "safe-sensitive" work tasks. In addition, the advantages of shorter shifts are the efficiency is likely to be maintained (Folkard & Tucker, 2003).

Basic Structure

Shift systems describe the sequence of how workdays are related to days off (Miller, 2006). Costa (2003a) states that this must be considered to ensure adequate recovery is provided for the workers. Åkerstedt (2003) emphasizes that the effects of irregular work hours seem to remain and affect the days off work. Depending on whether an eight-hour or twelve-hour shift is used, the number of free days employees are off work varies. Using twelve-hour shift provide twice as many days off work during a year, compared to eight-hour shift since the working time is compressed. However, more continuous days off work might provide an environment where employees engage in other work-related activities when they are off work and thereby not recover enough (Miller, 2006).

Interactions

If using a fixed shift structure, subcultures might develop disputes and lack of fairness between the shifts (Miller, 2006). For example, the hourly pay rates usually differ between day and night shift. If the salary is consistent, the number of hours for each shift can be adjusted. Another negative impact fixed shift might cause is a culture and division within the company with "us and them" thoughts between the crews. By using rotating shifts, everyone works all shifts, which reduces the risk of breeding a divided organization, and increase collaboration and performance.

3.3 Efficiency Losses

When shift work is applied, there are significant variations during the day in how efficient the work is performed (Folkard & Tucker, 2003). Changes are presented in Figure 1, which elucidate that the day-shift is the most efficient, followed by the evening-shift and with the night-shift as the least efficient. According to Costa (2003a), statistical information shows that the most used shift system is morning and afternoon shifts. Folkard and Tucker (2003) explain that the variation is caused by shortened and disturbed sleep, which leads to disrupted circadian rhythms and disturbance in the social life. Even if shift work can shorten the construction time, there is a risk that the productivity per worker decrease, caused by insufficient coordination, sleep, increased errors and accidents, and reduce the productivity of a project up to 17 percent. (Hanna et al., 2008).

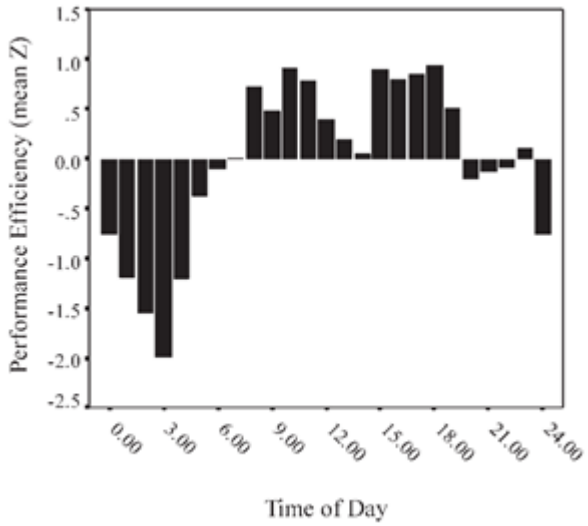


Figure 1: Performance efficiency during the time of the day (Folkard & Tucker, 2003).

Some of these problems could be avoided by improving the cooperation between the shifts, through an overlap when changing shifts, to reduce misunderstandings and to improve communication between the crews (Hanna et al., 2008). However, the overlap affects the efficiency negative by reducing the number of value-adding hours each crew produces. The question is if the advantages of working with shift will weigh over the negative impacts. According to Hanna et al. (2008), small uses of organized shift work can lead to a production that is more efficient and the negative impacts must be taken into consideration when implementing shift work, and the safety evaluation must be done more carefully.

3.4 Health Issues Caused by Shift Work

To get an understanding of how shift work affects the health, direct and indirect impacts will be assessed in this chapter. Also, clarifying the correlation between the organizations, individual and social aspects, that could be derived from shift work (Knutsson, 2003). Known direct effects of shift work are increased risk of accidents and work-related injuries (Folkard & Tucker, 2003). It is harder to verify that the

indirect impacts are caused by shift work when they can be expressed in both short-term or long-term (Knutsson, 2003).

3.4.1 Direct Work-related Injuries

Compared to other industries, the construction industry experiences a higher number of workplace accidents and fatalities (Marks, Awolusi, & McKay, 2016). When an accident occurs at a construction site, it is not always caused by one single action, but rather a sequence of several interlinked factors that together result in the accident (Li & Poon, 2013;2014). The interlinked factors that lead up to an accident can be divided into direct and indirect causes, and Li and Poon (2013;2014) argue that it is essential that the managers identify the indirect causes when an accident occurs and do not only focus on the accident itself.

3.4.1.1 Direct Causes

The direct causes are dependent of the site conditions which eventually leads to an accident, insufficient use of protective measures, such as safety gear and safety training, are part of the relevant site conditions (Li & Poon, 2013;2014). This is also supported by Spangenberg et al. (2003) who argue that education and experience, training and learning, and general attitude toward safety are factors which affect the risk of accidents. Li and Poon (2013;2014) state that continuous changes in the process, new construction site plans, and new drawings and procedures are direct causes to accidents when it requires a high level of coordination among the participating companies.

3.4.1.2 Indirect Causes

The indirect causes of work-related injuries are human errors, economic pressure and time pressure (Li & Poon, 2013;2014). Costa (2003a) argues that sleepiness, sleep disturbance and chronic fatigue can be important contributing factors to "human errors", which are likely to cause work accidents and injuries. It will likely affect workers response toward risk, relationship on the construction site, openness toward communication of safety and motivation to short-term benefits, which Li and Poon (2013;2014) describe as the structure of human errors. Furthermore, Li and Poon (2013;2014) argue that immense economic or time pressure might reduce consideration of safety procedures, which would likely to be time and resource consuming and thereby reduce efficiency and be an expense to the contractor.

In addition to the direct and indirect causes of accidents, there is a clear correlation between both the length of a shift and time since last break to the risk of accidents (Folkard & Tucker, 2003). In Figure 2, the left chart presents the correlation between the shift length and the relative risk of accidents where it is a distinct elevation of relative risk when the length of the shift increases. This risk aggregation becomes evident when the twelve-hour shift is compared with working eight hours or less. The reduction in risk between the five-hour shift and six-hour shift is explained by Folkard and Tucker (2003) through the introduction of a compulsory brake, which reduces the risk for the seven- and eight-hour shift as well. This theory is supported by another finding from Folkard and Tucker (2003), which state that the risks of accidents increase with the minutes since last break, which is presented to the right in Figure 2.

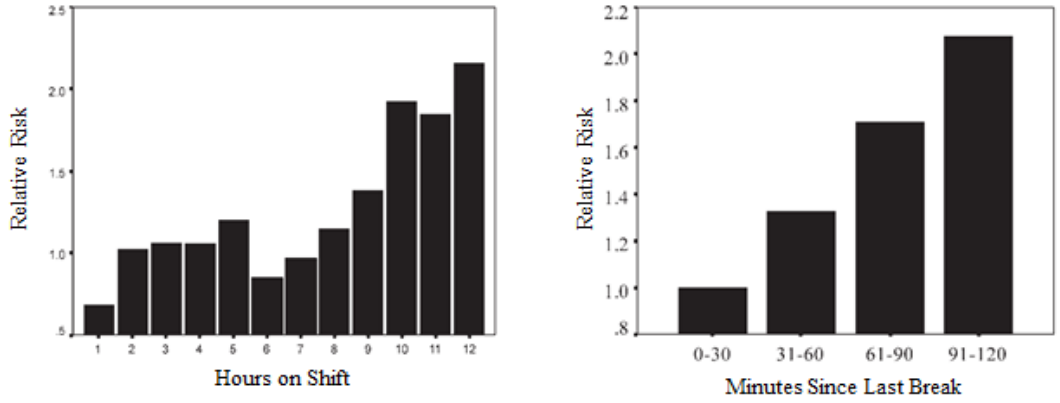


Figure 2: To the left: Correlation between risk of injuries and length of the shift. To the right: Correlation between risk of injuries and minutes since last break (Folkard & Tucker, 2003).

3.4.2 Indirect Diseases

The society is continuously changing which follows by changes in economic strategies and productivity strategies for organizations (Costa, 2003b). Costa (2003b) mentions the term "24-hours society" which means that the society no longer is limited to standard human activities hours. The requirements have increased in the recent years, followed by changes of organizational structures to meet the demands. It is however crucial that companies find a balance between increasing the financial revenues and the health effects to the workers. Styhre (2012) state that some roles in the production, such as the site management, takes the consequence of the high level of unpredictability in the construction industry, which can cause mental stress and physical health problems to the site management.

According to Knutsson (2003) research over the last decades has also shown that shift work can cause sleep problems which can result in increased stress, psychological and social issues. There is also an indication that some individuals are more suitable for shift work than others are, and it is the physical condition as well the psychological conditions that together with the social situation will have an impact on the tolerance of shift work. Figure 3 illustrates the possible mechanism of impacts related to shift work (Knutsson, 2003). The circadian rhythms, behavioral changes, and disturbed socio-temporal patterns are the first indications of a negative impact of shift work. These three mechanisms could further lead to more severe problems, which are interrelated with each other. Unless these problems are not noted, the consequences of shift work could lead to diseases of varying severity.

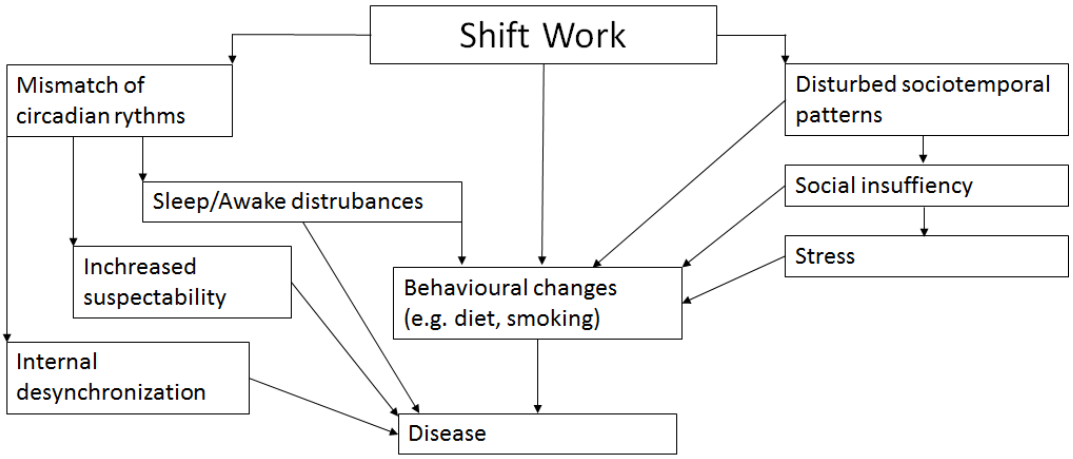


Figure 3: Disease mechanism in shift work (Knutsson, 2003)

3.4.2.1 Disturbance of Circadian Rhythm

One of the core consequences caused by shift work is a disturbance in the circadian rhythm, which is associated with several subsequent health effects (Åkerstedt, 2003). This is supported by Costa (2003b) who argues that changes in the circadian rhythms are often related to disturbance of the normal sleep rhythm. Åkerstedt (2003) states that under optimal conditions, the human body can adjust to a new circadian cycle at a speed of one hour per day. Biologically, working during hours that changes the circadian rhythms will force workers to acclimate to the shift period. According to Åkerstedt (2003) this indicates a progressive phase to change the rhythms, but an absolute adjustment is rarely seen. Many problems start with disturbance of the normal circadian rhythms and could potentially have consequences for safety and productivity. Williamson, Lombardi, Folkard, Courtney and Connor (2011) state that several of the most severe working place accidents have occurred at times when people usually sleep, for example, Estonia Ferry, Three Mile Island, Chernobyl and Rhine Chemical Spill. Further, Williamson et al. (2011) argue that sleep deprivation and time since waking affects performance and causes increased number of accidents and injuries.

3.4.2.2 Behavioral Changes

As a result of shift work, workers sometimes obtain irregular habits in food consumption as well as an inadequate diet (Lowden, Moreno, Holmbäck, Lennernäs, & Tucker, 2010) Further, Lowden et al. (2010) state that there are indications that shift work can affect metabolism and appetite. The fact that workers of the evening and night shift are unsynchronized with surrounding environment makes it harder for them to follow a strict and healthy diet. Shift workers then have a higher risk for metabolic disorders and eventually diseases, compared with day-workers. Waterhouse, Buckley, Edwards and Reilly (2003) argue that the unhealthy gastronomical effects night work entail of food intake extends after the shift is ended which prolong the adverse effects. According to Lowden et al. (2010), evening and night workers generally eat more frequently and unhealthier compared to day workers, and are caused by biological, social and cultural factors which makes it hard to adopt new conditions through shift work.

Health behavior could also occur through increases in coffee consumption and other drugs, to help workers stay awake (Lowden et al., 2010). In the study, presented by

Lowden et al. (2010), research shows that longtime evening and night workers tend to have an increase of body mass index and the activity level has been shown to decrease for these workers. This is supported by the study conducted by Karlsson, Knutsson and Lindahl (2001), which indicates that there is an elevated risk for metabolic syndrome among shift workers, through increased obesity and harmful cholesterol. Moreover, inconvenience work hours could also entail an adverse effect on habits (Chung, Lee, & Kim, 2016). Lowden et al. (2010) emphasize the risk of behavioral changes through smoking or alcohol problems, which over time can affect both the private life and the working life. To reduce the negative impacts on behavior, Lowden et al. (2010) mean that the workers should strive toward following the biological clock, with regular sleep and eating habits.

3.4.2.3 Disturbance of Social Patterns

There is a risk that shift work can affect workers' social relationships (Costa, 2003b). Workers could face difficulties to be involved in activities in society and to handle their social lives, due to most activities are arranged to fit "normal" working times. This is supported by Harrington (2001), who states that shift work can affect family and social activities. Furthermore, Harrington (2001) argues that disturbance in circadian rhythms and not be able to fulfill personal obligations, such as childcare, housework and sports activities can result in psychological strain for the workers.

Several psychological and physical diseases can be associated with long-term disturbance of the social patterns with sleep disorder, fatigue and stress as some of the early symptoms (Harrington, 2001). Long-term disturbance of social patterns can, according to Harrington (2001), have an impact on the mental health, causing cardiovascular and gastrointestinal diseases and reduce performance. Anxiety, depression and emotional instability are examples of impact on the mental health caused by shift work, which is supported by both Harrington (2001) and Chung et al. (2016), who argue that it is due to disturbance of the biological clock.

There is however no clear evidence supporting that shift work has a direct effect on the longevity of the employees (Åkerstedt, Kecklund, & Johansson, 2004). This assertion is supported by Karlsson, Alfredsson, Knutsson, Andersson and Torén (2005) who argue that there is no observation of a general increase in mortality among shift workers compared with day workers. Nonetheless, according to Karlsson et al. (2005), there might be an elevated risk of coronary heart disease among shift workers with exposure to long duration of shifts. Both research teams argue that the research in this area is insufficient, and thereby it cannot be confirmed that there is no link between shift work and mortality (Åkerstedt, 2004 & Karlsson et al., 2005). Several researchers agree that it is the night shift that has the considerable impact on the workers, and it is the night shift that disturbs the circadian rhythms and the social patterns in the greatest extent (Harrington, 2001; Chung et al., 2016 & Costa, 2003b).

3.4.2.4 Effects on Individual Conditions

The general factors, which are affecting the workers' tolerance or intolerance of shift work are dependent on family & living conditions, social conditions, individual characteristics, working conditions and working hours (Costa, 2003a). The factors integrate with each other and create conditions for each individual.

Costa (2003a) emphasizes the importance of the organization's ability of adjustment to help workers adapt to the organization without putting their health into too excessive risks and to value workers' personal conditions and their degree on tolerance. The process of change should not be done through only selecting workers with a high tolerance for shift work, rather should the organization see the individual of the organization and match their values to the shift system. Demerouti, Geurts, Bakker and Euwema (2004) state that flexibility in shift structure, length, position and duration of the working time, can be suitable means to adapt the working conditions to individual preferences and needs, which can increase job satisfaction and reinforce a positive attitude towards the job and work time arrangements. Costa (2003a) highlights that companies cannot adopt the shift system to all aspects of all individuals and must instead try to match as many aspects and variables as possible to the majority of the workers. By assessing these aspects, it is possible to increase the efficiency and motivation of the workers, and over time increase the profit.

In addition, by implementing an additional shift, it is possible to reduce occasional overtime and inefficiency problems connected to physical fatigues. In the construction sector, much responsibility lies with the site manager (Hanna et al., 2008). This is supported by Styhre (2012), who argues that site managers have the full responsibility of economy and production, simultaneously as they are involved in the everyday, nitty-gritty concerns, which expose the site manager to a considerable amount of stress. This often results in high overtime work, which, could lead to physical fatigues caused by much pressure. Further, Styhre (2012) argues that site managers in the construction industry face a high level of unpredictability, which requires more decisions that are ad hoc and less time long-term planning.

3.5 Impact on Society

Construction projects, especially in urban areas, are likely to impact the surrounding environment (Hyari, El-Mashaleh, & Rababeh, 2015). Social costs, as a result of construction-related negative impacts, can be identified through Traffic, Economic and Ecological/Social/Health systems (Gilchrist & Allouche, 2005). The magnitude of social costs can, according to Gilchrist and Allouche (2005), in some cases exceed the direct cost of production by several times. However, even though the social costs may be dramatic, they are rarely considered in the design, planning or bid evaluation phases of construction projects today. Therefore is the impact on society, caused by construction work, of high relevance when evaluating when the conditions are suitable for shift work.

3.5.1 Traffic

It is likely that urban construction projects will have an adverse impact, and affect the availability of a city's infrastructure (Gilchrist & Allouche, 2005). Hyari, El-Mashaleh and Rababeh (2015) argue that the additional traffic volume, produced by construction traffic and by the additional conflict points, entrance and exit of the site, during construction, causes delays and traffic congestions. The most vital areas affected by construction are, according to Gilchrist & Allouche (2005), prolonged closure of road space, detours, delays, utility costs, loss of parking space, increased fuel consumption and increase traffic accidents. There are also indications that being

exposed to a congested traffic environment can result in increased stress (Hennessy & Wiesenthal, 1997).

3.5.2 Economic

Construction work can have a negative economic impact on the surrounding community, which is pointed out by Gilchrist and Allouche (2005). According to Gilchrist and Allouche (2005), large-scale urban constructions can have a considerable impact on the local business sales through reduced accessibility. Construction projects can also affect by reduced productivity through annoyance and by causing concentration difficulties. The economic effects of construction can end up affecting personal income of business owners and in the end, reduce the tax base within the project's influencing zone.

Property damage is also an area Gilchrist and Allouche (2005) highlight as vital when it comes to the economic effects generated by construction. They argue that construction projects can cause damage to structures nearby due to settlements caused by equipment vibrations or by dewatering activities, it can also come through directly affecting the property with machines or when handling material.

3.5.3 Ecological, Social and Health Systems

Pollution-associated impacts may reduce the quality of life within a project's influencing zone, affecting human health and resting periods (Gilchrist & Allouche, 2005). Air pollutants and dust can have a physiological impact and noise pollution can have a psychological impact. According to Gilchrist and Allouche (2005), additional costs, associated to physiological and psychological impacts, can be found in the consumption of healthcare services and sick-leaves. In Sweden, the construction industry must consider and adapt production to the guidelines of noise generation in urban areas. Naturvårdsverket (2004) has established restrictions of maximum noise levels that vary depending on the time of the day, the day of the week and type of activity in the surrounding buildings, such as health care and education. It is during the day, between 7.00 am to 7.00 pm, the regulations are least strict with 60 decibel at facade and increases to reach a peak during Sundays from 5.00 pm to 10.00 pm and all nights between 10.00 pm and 7.00 am with 45 decibels at the facade.

Naturvårdsverket (2004) states that the regulations should be used as a starting point but individual assessment should be conducted when necessary. Also, if the restrictions cannot be reached with available technical solutions, or if it is not financial supportable, the aim is to come as close as possible to the values. Measures to reduce noise is to temporary build in the noise generating activities, using noise reducing covers or walls (Naturvårdsverket, 2004). Providing the surrounding neighbors with information such as during which time-period they might expect high construction noise is something that should be done.

4. Financial Evaluation

This chapter adds the economic dimension to the thesis and will reinforce the discussion by identifying whether there are economic incentives for using shift work to a broader extent. In the evaluation, eight shift structures are compared, two eight hour shift, eight and seven-hour shifts, eight and six-hour shifts, and double seven days shift. Each shift structure will be further presented after the general presumptions, common for all evaluated shift structures. The calculation will provide a simplified view of how a 2-shift system affects the budget and time plan of the studied construction project. How noise pollution would impact the evaluated project has been disregarded, and it is assumed that the project is located so that work can proceed without disturbing the surrounding environment.

4.1 General Presumptions

There are several factors in the theoretical framework indicating it would be more beneficial to use an eight-hour shift over a twelve-hour shift in the construction sector since the level of safety and productivity is declining with the length of the shift (Folkard & Tucker, 2003). Miller (2006) also argues that twelve-hour shift is inappropriate when the work includes heavy physical work, demanding and repetitive work, safety-sensitive work, public safety-sensitive and when sustained alertness is required, all of which is found in the construction sector. Therefore will eight-hour shifts be the evaluation point when conducting the financial comparison. Six- and seven-hour shifts are alternative shift structures that will be studied in the financial comparison, and are according to Miller (2006) suitable alternatives to use in the construction industry. One of the shift structures evaluated uses longer shifts than eight hours, the double seven days shift, which, according to Miller (2006) and Hanna et al. (2008), might not be the most suitable system for the industry. However, from the interviews conducted in this thesis it was found that when shift work is applied in projects, the double seven days shift is one of the more commonly used, and will therefore be part of the financial evaluation.

A number of researchers emphasize that it is the night shift which, in the greatest extent, have a negative health impact such as disturbance of the circadian rhythms, social pattern and behavioral changes (Harrington, 2001; Chung et al., 2016; & Costa, 2003b). Besides, the night shift entails the most significant loss in production efficiency and is highly limited by the noise regulations (Folkard & Tucker, 2003; & Naturvårdsverket, 2004). The compensation of the workers is significantly higher during the night shift which substantially reduces the profitability (Seko, 2018 & Byggnads, 2017). Therefore will all shift structures in the financial evaluation be based on a 2-shift structure, day and evening shift and weekly shifts, which constitutes productivity improvement without too severe impact to the workers. By only using a 2-shift structure working day and evening, the number of crews required will be two.

An important variable in the financial evaluation is overlap and what length required. Based on the experience of the interviewees and the overlap used in production today, both 15 minutes and 30 minutes overlap were chosen for the evaluation. For the double seven days system, only one overlap per week is required, the studied length is either 30 minutes or 1 hour. The overlap, which is necessary to enable collaboration between the shifts, will however not be considered value-adding time

to the production and therefore reduce the number of hours worked per day. This is because the overlap is considered a requirement in shift work, and otherwise not used, which cause the overlap to be non-value adding.

Shift structures with shorter shift length, seven-hour and six-hour shift, can reduce the number of compulsory breaks in the shift, which eventually may lead to opposition among the workers result in extra costs. When this is the case, production losses linked to starting up and shutting down work before and after a break will be eliminated ((Jacobsson & Jacobsson, 2012); (Jodal, 2011); & (Leinonen & Montell, 2016)). Therefore will shifts, with fewer interruptions, compensate the startup and shutdown process of each break with 20 minutes per break, 10 minutes before and 10 minutes after the break, which otherwise would be wastage, and prolong the value-adding time. In the calculation, all shift systems use a slow rotating structure, which, according to Miller (2006), gain the advantage of reduced divisions between the shift teams. However, using a rotating structure increases the risk to disturb the circadian rhythm (Åkerstedt, 2003)

When shift work is applied, the costs of the project will either remain the same, decrease or increase, and how the cost change is based on the experience of the employees interviewed in empirical findings and through existing laws and regulations. The hourly compensation of the workers increases with a predetermined percentage, depending on day and time the work is performed. In Sweden, the salary of construction workers is built on two collective agreements between the Swedish Construction Federation and The Swedish Building Workers Union (Byggnads, 2017) and Road and Rail Union (Seko, 2018). The construction workers can be members of both unions simultaneously and depending on a project's preconditions, one of the two agreements is used. The given conditions for the studied project entail that the Seko (2018) is used, which will be the primary legislation in the calculations. Stated in the Seko (2018) is that the total working time may be up to 13 hours per day with a minimum rest period of 11 hours, which affects and forces the double seven days shift structure to limitations. When a two-shift system is used, workers cannot exceed the maximum of 38 working hours per week in average, for work above the ground which is where most of the projects for the studied department of the organization are executed. Besides, there is a law stipulated to control the maximum number of continuous hours allowed to work without breaks, Arbetsmiljöverket (2016). This law declares that if work is performed for more than five hours, employees are entitled to a 30 minutes break, which is taken into consideration when the shifts are formed.

The construction workers' agreement, Seko (2018), compensate the workers for inconvenient working hours according to Table 1. The compensation is based on time of the day and adds salary to the workers' monthly income, and is presented below the table.

Table 1: Additional hourly compensation for members of the Road & Rail Union for inconvenience working hours, with construction workers´ monthly salary as compensation base, (Seko, 2018).

	Monday-Thursday	Friday	Saturday	Sunday
05.00-06.00	OB1	OB1	OB3	OB3
06.00-17.30	ORD	ORD	OB3	OB3
17.30-19.00	OB1	OB1	OB3	OB3
19.00-22.00	OB1	OB3	OB3	OB3
22.00-05.00	OB2	OB3	OB3	OB3

$$ORD = Ordinary\ salary$$

$$OB1 = \frac{Monthly\ salary}{616}$$

$$OB2 = \frac{Monthly\ salary}{280}$$

$$OB3 = \frac{Monthly\ salary}{154}$$

The compensation for office workers is regulated through Tjänstemannaavtalet (Unionen, 2017). This agreement states that compensation for shift work is adjusted through written agreements between the local parties of the company. By internal information from the studied construction company, following agreement is presented in Table 2.

Table 2: Compensation for members of the Union, office workers, for regulations for inconvenience working hours, (Unionen, 2017).

	Monday-Friday	Saturday	Sunday
05.00-06.00	OB1	OB2	OB3
06.00-17.30	ORD	OB3	OB3
17.30-22.00	OB1	OB3	OB3
22.00-05.00	OB2	OB3	OB3

$$ORD = Ordinary\ salary$$

$$OB1 = \frac{25\ \% * monthly\ salary}{175}$$

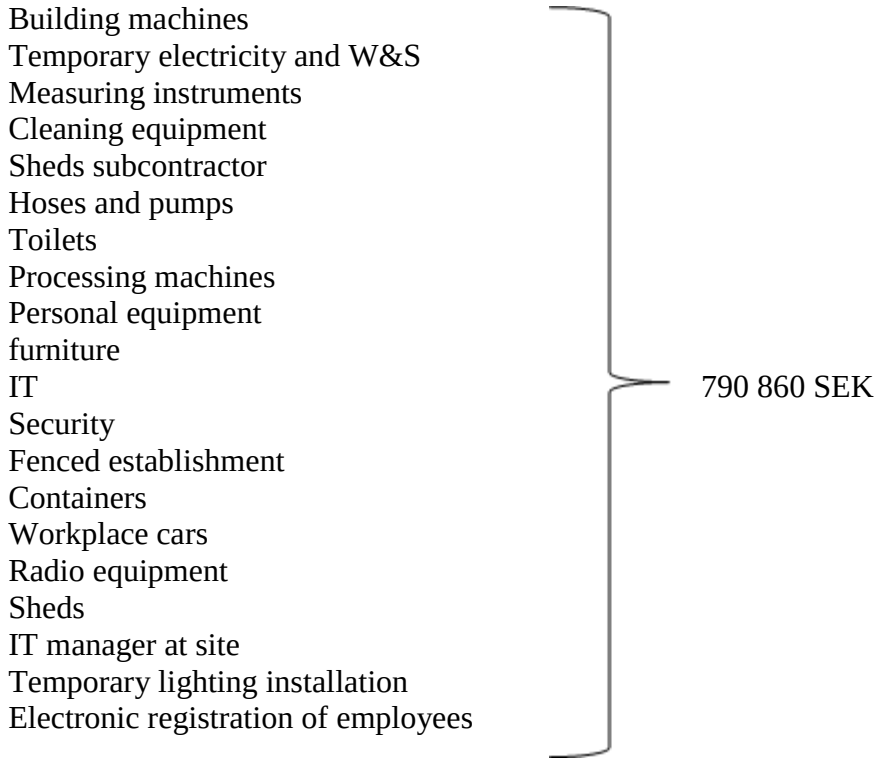
$$OB2 = \frac{55\ \% * monthly\ salary}{175}$$

$$OB3 = \frac{100\ \% * monthly\ salary}{175}$$

These collective agreements have been used to assess the increase in labor cost for the project. To get a complete overview of the cost changes for the subcontractors, an interview with a side-contractor supplying bitumen, representing one-third of the total budget of all subcontractors, great insight of how shift work would affect their budget were acquired. It was then assumed that all subcontractors' costs would be affected by shift work in the same way as the Bitumen contractor. Additionally, an assumption has been made that external suppliers can deliver to the project without additional cost when working inconvenient working hours, through adequate planning and that the suppliers can acclimate to chosen shift system.

Shift work will probably reduce the project's time plan, but to what extent depends on how many value-adding hours each shift system generates per working day and the cooperation between the shift teams. How the cost of the project will differ with two shifts will mostly depend on the amount of fixed cost of the project in relation to the increase in labor cost. The fixed costs are only connected to how many days the project is running and not to how many hours per day work is performed.

Thereby, reducing the time plan through shift work is one incitement to maximize the number of value-adding hours of the day to reduce the fixed cost. In the evaluated project of this thesis, the following costs are fixed costs which in the financial analysis, will decrease when shift work is applied.



The presented costs of the project represent an estimation of the total amount of fixed costs which is 790 860 SEK. How much this sum will decrease depends on to what extent the time plan for the project can be reduced. In addition to these opportunities to reduce the costs of the project, it is assumed that no incentives are given from the client through a shortened schedule and that the tender sum is unmodified. An assumption is also that the cost of renting equipment will remain for the subcontractors and thereby for the project. Highlighted in the empirical findings, is that there is a need for the production flow to maintain constant over time which is a presumption made in the calculations. Neglected in the calculations is also that additional cost for the contractor to maintain the same level of planning through the project and for the additional initial planning that needs to be done when evaluating if shift work is a possible solution for the project. Neither has the eventually increased employment ratio costs been taking into consideration when assessing the project.

4.2 Shift Systems

This chapter will provide a base for establishing an evaluation model with a framework of criteria to fulfill before implementing shift work in projects. Presented underneath are the descriptions of all shift systems with the corresponding abbreviation.

8 hours / 8 hours with 30 minutes overlap	8/8a
8 hours / 8 hours with 15 minutes overlap	8/8b
8 hours / 7 hours with 30 minutes overlap	8/7a
8 hours / 7 hours with 15 minutes overlap	8/7b
8 hours / 6 hours with 30 minutes overlap	8/6a
8 hours / 6 hours with 15 minutes overlap	8/6b
7 days / 7 days with 2 hours overlap	7/7a
7 days / 7 days with 1 hour overlap	7/7b

4.2.1 Double Eight-hour Shift

The 8/8a and 8/8b shifts will be limited by the Seko (2018) where the average working time is restricted to 38 hours per week. Thereby, the production time will be reduced, both due to the regulations of Seko (2018) and because of the overlap time.

30 Minutes Overlap

This shift structure, 8/8a, is made up of an eight-hour shift, starting at 5.10 am, followed by the second eight-hour shift starting 2.30 pm, working Monday to Friday. The overlap between the 8/8a shift is 30 minutes, between 2.30-3.00 pm. Each shift has one hour of break, divided over three times where one is 30 minutes and assigned to lunch or dinner, and the other two are 15 minutes each. Taking into account reduced production efficiency by the overlap and regulation of Seko (2018), the value-adding time of this shifts are in total 14 hours and 10 minutes.

15 Minutes Overlap

This shift structure, 8/8b, have similarities with the 8/8a shift system, where the main difference is the overlapping time. To utilize the time, the inconvenience working hours and the overtime premium, the working times for the 8/8b system have different working hours. The first shift starting at 5.10 pm, followed by the second shift starting 1.45 pm, working Monday to Friday. The overlap between the 8/8b shifts is 15 minutes, between 1.45-2.00 pm. Each shift has one hour of break, divided over three times where one is 30 minutes and assigned to lunch or dinner, and the other two are 15 minutes each. When considering the reduced production efficiency, the value-adding time of this shifts is in total 14 hours and 50 minutes.

4.2.2 Eight- and Seven-hour Shift

30 Minutes Overlap

This shift structure, 8/7a, has one eight hour shift, starting at 5.45 am, with a following seven-hour shift starting at 2.15 pm. This shift structure is working Monday to Friday and uses a 30 minutes overlap between the shifts from 2.15-2.45 pm. The first eight-hour shift has one hour break, divided into three periods. The second, seven-hour shift, only has two breaks, one 30 minutes and one 15 minutes, resulting in this shift compensates for production losses with 20 minutes, as presented in the general presumptions above. Losing one hour in the overlap and compensation with 20 minutes for increased production efficiency, the value-adding time of this shift is 14 hours 33 minutes.

15 Minutes Overlap
This shift structure, 8/7b, have similarities with the 8/7a shift system, where the overlap in this shift system is 15 minutes instead of 30 minutes. The first shift starts at 5.45 am and the second shift starts at 2.15 pm. Also in this shift structure, the working days are between Monday and Friday and unlike the 8/7a system, this shift system has an overlap between the shifts from 2.15-2.30 pm. The first eight-hour shift has one hour break, divided into three periods. The second with seven-hour shift, has only two breaks, with in total 45 minutes, resulting in 20 minutes increased efficiency due to a reduction in the number of breaks, resulting in a value-adding time of 14 hours and 50 minutes.

4.2.3 Eight- and Six-hour Shift

30 Minutes Overlap
This shift system, 8/6a, uses first an eight-hour shift, starting at 5.00 am, with a following six-hour shift starting at 1.30. The six-hour shift will only include the one 30 minutes break that Arbetsmiljöverket (2016) requires, and the second shift work until 8.00 pm Monday to Friday. Working with only one break correspond to two 20 minutes startup and shutdown processes. One hour is lost to overlap between the shifts which make the value adding time for this shift system 13 hours and 40 minutes in total.

15 Minutes Overlap
This shift structure, 8/6b, has a similar structure as the 8/6a, but with a difference in the length of the overlap which in this system has 15 minutes instead of 30 minutes. The first eight-hour shift starts at 5.00 am, followed by the second six-hour shift starting at 1.45 pm and with working days between Monday to Friday. As in 8/6a the second shift must take Arbetsmiljöverket (2016) into consideration and have one 30 minutes break, resulting in 40 minutes increased efficiency, because of the reduction of startup and shutdown processes. 30 minutes are lost in overlap which results in a value-adding time for the shift system of 14 hours and 10 minutes.

4.2.4 Double Seven Days Shift

1 Hour Overlap
The value adding time for this shift system, named 7/7a, is based per week and not per day. The structure of this shift system is 6.00 am to 6.45 pm Monday to Friday, and 6.45 am to 5.15 pm Saturday and Sunday. This shift system only requires one overlap for each week, and this overlap is however settled to be one hour, which corresponds to two hours in lost production time for the two shifts, each week. Total hours of value-adding work for the week is 74 hours, which generate an average working week of 37 hours of value adding time.

30 Minutes Overlap
The structure of this shift system, 7/7b, is like the 7/7a system based on a weekly basis. The shifts are divided into weeks where the first shift works Monday to Sunday before the next shift takes over. The shift starts at 6.00 am until 6.45 pm Monday to Friday, and 6.45 am to 5.15 pm on Saturday and Sunday. With only 30 minutes overlap between the shifts every Sunday, the total loss in production time is one hour which results in 75 hours in value adding time, which generate an average working week of 37 hours and 30 minutes of value adding time.

4.3 Results

The result of the financial evaluation is presented in Table 3 and Table 4 later in this chapter. In the two tables, there are several key factors, vital for the final change in profit. These key factors will be presented before introducing the result.

OB Hours Construction Worker - Additional cost of work performed by construction workers at inconvenient hours, presented as the number of regular working hours the two shifts work adds on to the double eight hours. A high value indicates that the shift structure is expensive and much of the work is performed at inconvenient working hours.

OB Hours Office Workers - Additional cost of work performed by office workers at inconvenient hours, presented as the number of regular working hours the two shifts work adds on to the double eight hours. A high value indicates that the shift structure is expensive and much of the work is performed at inconvenient working hours.

Value Adding Hours - This factor presents how many hours of the daily time construction available for value adding work is performed. A high number indicates an efficient shift structure with low losses embedded. Value adding hours is essential to the outcome because it affects the construction time and thereby the reduced fixed cost and increased turnover.

Increased Turnover - The regular working time is eight hours per day, 16 value adding hours would entail a shift to reduce the construction time to 50 percent and double the number of projects performed during the year. However, the value-adding hours have, through the overlap, an embedded efficiency loss which will reduce the turnover.

Additional Cost - Using shift work entails a higher labor cost for construction workers, office workers, and subcontractors. These additional costs are based on the compensation inconvenient working hours entails depending on the specific agreement for the parties.

Reduced Fixed Cost - As stated above, the reduced fixed cost is related to value adding hours of each shift which controls the construction time.

Profit After Shift - After adding and subtracting all additional costs and cost reductions shift work entails, profit after shift is the gross profit generated in the project. The studied company had set a 7 percent gross profit in the early calculations of the project, which the result will be compared to.

Capital Turnover - By using shift work, the construction time can be reduced, to what extent is regulated by the number of value-adding hours as well as the turnover. This factor takes this into account for the shift and increases the profit after shift, based on the value-adding hours of the shift.

Change in profit - A ratio that compares the increased turnover to the 7 percent gross margin that initially was the economic goal of the project.

Table 3: Result of financial evaluation of shift with long overlap

		8/8a	**8/7a**	**8/6a**	**7/7a**
OB Hours Construction worker		17,8	17,7	17,0	20,4
OB Hours Office-Workers		17,1	17,0	16,7	19,9
Value adding hours		14,17	14,33	13,67	14,8
Additional cost	SEK	863 682	764 928	870 594	1 330 333
Fixed cost	SEK	−344 257	−349 450	−327 918	−363 368
Profit after shift		2,90%	3,80%	2,70%	−0,80%
Increased turnover		5,14%	6,81%	4,62%	−1,48%
Change in Profit		−29,56%	−3,03%	−34,25%	−121,02%

Table 4: Result of financial evaluation of shift with a short overlap

		8/8b	**8/7b**	**8/6b**	**7/7b**
OB Hours Construction worker		17,8	17,8	17,2	20,4
OB Hours Office-Workers		17,1	17,1	16,8	19,9
Value adding hours		14,70	14,83	14,17	15,0
Additional cost	SEK	707 657	668 015	749 601	1 210 082
Fixed cost	SEK	−360 460	−364 233	−344 257	−369 068
Profit after shift		4,40%	4,79%	3,89%	0,22%
Increased turnover		8,09%	8,88%	6,89%	0,41%
Change in Profit		15,13%	26,30%	−1,93%	−94,23%

There are indications from the calculations of what are cost driving and what might be cost saving factors. Firstly, shifts with many OB Hours ends up with low *Profit after shift*, and thereof a low *Change in profit*, like the shift structures 7/7a and 7/7b. It can also be noticed that all shift structures with less overlap had a higher profit compared to the correspondent shift structure with longer overlap. Also that the *Reduced fixed cost* is quite even for all shifts, which indicate that it is not the most vital factor for determining whether a shift will entail an increased profit. The shift structures with the outstanding best economic results were 8/8b and 8/7b, which both indicate that the profit can increase, for 8/7b up to 26 percent. The critical factor separating these shift structures is a combination of high value-adding hours and relatively low additional OB hours, which result in high turnover to low cost.

There are also a number of possible adverse consequences that shift work might cause, such as costs due to coordination, cooperation and transfer of knowledge between the shifts. Also the fact that the working hours might adversely affect the attractiveness of the company, resulting in additional costs. The 8/8 shift systems' first shift start at 5.10 pm, which is hard for most of the workers to cope with, as well as the evening shift which might affect their social life. The decided working hours for the shifts are mainly established to fulfill and optimize the regulations from Seko (2018) and Unionen (2017), but still, further consideration of the human needs has to be done before implementation. These unknown consequences are harder to evaluate, which is something that future research has to investigate.

5. Empirical Findings

To strengthen the results of the economic evaluation, and add the dimensions of experience and understanding, selective interviews have been conducted with vital members of the production organization, support functions to the organization, subcontractor, and client to the organization. The interviewees have different roles in or connected to the production process and are thereby able to contribute with varying views of how the production can be affected by shift work. To receive a high level of authenticity and credibility of the answers in the interviews, the interviewees will be presented anonymously to protect their integrity. Roles of the interviewees are:

Construction Worker A	*On site*
Construction Worker B	*On site*
Construction Worker C	*On site*
Site Manager	*On Site*
Supervisor	*On site*
Operative Manager	*Support*
Planning Manager	*Support*
HR Manager	*Support*
Technical Manager	*Support*
Sale and Customer Manager	*Support*
Project Manager	*Client*

From the interviews, the collective view of the most critical questions, threats and opportunities have been compiled into the chapters that follow. The most vital and relevant subjects are discussed to identify what areas that might require further attention in upcoming projects.

5.1 Challenges the Construction Industry Faces

According to the *Operative Supervisor*, there is a lack of competence throughout the industry. The problem exists among the construction workers, managers, consultant and clients, which leads to problem in both quality, time, cost and safety. This is supported by the *Site Manager* who states it is difficult to find employees and even harder to find ones with the adequate experience. There can be implications if there are only inexperienced supervisors in a project, resulting in such as delays, errors or accidents. There is also an extensive replacement of generations taking place in the industry the years to come, and the gap in knowledge can already be observed, argues the *Construction Worker A.* The experience and knowledge of how to perform the construction work lies with the employees and not in the process, which results in a massive problem in a replacement in generations.

Another problem the construction industry faces, and has been struggling with for decades, is according to the *Planning Manager* the inability to increase the production efficiency. Other areas in the industry, such as safety procedures, have gone through considerable improvements while only little can be noticed in the core business. The *Planning Manager* argues that the technology and machinery to increase the production capacity exists, but there have been higher restrictions of how the construction is allowed to influence the society in the form of noise, environmentally and work regulations. The *Technical Supervisor* argues that the digital development that takes place in the industry will also require more detailed

documentation, controls and quality demands, which could be time-consuming and thereby further reduce the efficiency.

A reason why the construction industry stands out from other industries when it comes to improvement of efficiency is according to *Construction Worker A* that the construction industry faces a significantly higher level of uncertainty. The production can encounter unmarked cables and sewers and then it becomes vital to identify if they are active and who is the proprietor, which are both costly and time-consuming. The *Site Manager* argues that deliver pursuantly with the agreed contract is not difficult, but the contractor's role has developed into a service coordinator, and the client is able throughout the construction process to come with changes and additional work. The late changes and the high level of uncertainty make it hard for the contractor to plan their work strategy more carefully which, according to *Construction Worker A* and the *Site Manager*, are contributing factors to why it is hard to increase the work efficiency in the construction industry.

The cost of producing in the construction industry has increased while the efficiency was maintained at an equal level for many years, means the *Planning Manager*. According to the *Planning Manager*, preconceptions are indicating that shift work is not suitable for the construction industry. However, the industry needs to improve the efficiency, and this is a considerable challenge the upcoming years. The preconceived sentences of shift work are further confirmed when the question is asked why shift work is not used to a greater extent in the construction industry. The *Construction worker B* means, "You build mainly on traditions. The industry is traditional and conservative, which makes it hard to get employees to appreciate changes quickly, like shift work."

5.2 Barriers to Implementing Shift Work as a Standard Process

"It is obvious that shift work would be challenging to implement when it is difficult to find employees with competence and experience," states the *Operative Supervisor*. The market in Gothenburg has never been more intense then it is today, which makes it hard to keep the employees, and even harder to find enough to start the second shift. Both the *Site Manager* and *Construction Worker B* agree that a precondition for shift work is to have adequate employees and that there is a substantial risk of reduced safety if the employees do not have the right experience.

Another area, which is pointed out as vital when it comes to when shift work can be used, is the noise regulations in urban areas. Both the *Operative Supervisor, HR Manager, Planning Manager, Site Manager* and *Construction Worker B* state this as an essential restriction to when and where shift work can be used. The regulation is firmer at evening compared to the day, and this constrains specific work moment to the day which might disturb the workflow. The *Project Manager* is aware of the disturbance caused on the surrounding environment when implementing shift work, but by sharing information about the future environmental disturbance and sometimes by building temporary noise protections, the benefits can exceed the disadvantages of extended working hours.

There are support functions which today is adapted to the eight-hour workday, and that needs to adjust to the new working routines shift work requires, argues the *Site*

Manager. If a machine breaks, there is a lack of material, or if the production runs out of diesel on a Friday afternoon, the production would have to wait until Monday before it could be solved. However, these production problems could be prevented with an on-call service, states the *Planning Manager*. This is supported by the *Project Manager* who means that the project team has to be prepared for unforeseen events by having a substitutional plan for incidents during inconvenient working hours. The *Planning Manager* implies that it is costly if all companies that are involved in the construction would require these functions of availability during inconvenient working hours. Therefore, shift work might require more planning to ensure that the production can proceed outside the regular working hours, without full accessibility of support functions. However, it can be argued that it would be hard to find more time to do additional planning since the site organization already experience high level of pressure.

The *Technical Supervisor* emphasizes the importance that the design team must be experienced, so the drawings are correct, also that there might be a need of using shift work for the design team to ensure the workflow does not come to a standstill. The *Project Manager* explains that the client also becomes affected when the project is executed in shifts since they need to be available during the production time. According to the *Project Manager,* the extra cost for the client is insignificant compared to the production costs, although the competence has to be available even for the client.

The *Operative Supervisor* also argues that it is vital that the production flow for a crew is maintained. Shift work cannot be applied to all projects; therefore, shift work as a standard would come with a high risk. This risk is also pointed out by the *Sale and Customer Manager,* who adds that some work moments, performed by the subcontractors, are controlled by the temperature, and therefore the workflow cannot be maintained throughout the whole year. It would be extremely costly to have an organization that mostly does not contribute to increased profit, when the conditions for the execution is wrong. With shift work the organization becomes even more vulnerable. There is a boom in the construction industry today, but it is uncertain where the industry will be in the years to come. The question is, will it still be beneficial with shift work then?

To work shift puts a much higher strain on the employees, compared to the regular eight-hour work day states *Construction Worker B.* The *Construction Worker B* further states *"*When you work seven days straight, you are tired mentally and physically at the end of the week, mistakes occur, and the efficiency is reduced." This view is supported by the *Supervisor* and the *Planning Manager* who also point out the problem with lack of statistics of how accident rate is related to shift work.

The *HR Manager* believes that there is a risk of increased that the employment ratio if shift work were to be introduced to a more substantial extent. If people who have worked in this industry for many years, and are accustomed to the existing system, are forced into shift work, there is a significant risk that they change employer. Younger employees might be more interested in working shift, but then the crew is inexperienced which could result in lack of safety and knowledge. The *Project Manager* highlights the importance of respect the working environment. The client

has to ensure that the contractor is understandable of the extra effort that needs to be accomplished when shift work is used. The work must be done systematically, with proper planning routines and with adequate overlap between the shifts, to ensure that the same quality is reached.

5.3 Shift Work Today

Shift work is today used when there are economic incentives that exceed the increased costs and resource demands of shift work, argues the *Supervisor.* According to the *Site Manager,* it can also be used when working with a tough deadline. This is supported by the *Operative Supervisor, Technical Supervisor* and *Construction Worker B* who argue that time pressure in combination with activities requiring expensive machinery are conditions that allow for shift work. Example of this is tunneling projects which also have a low impact on the surrounding area in term of noise impact, and also has machinery costs linked to shut down the process, argues the *Technical Supervisor.* Brought up by the *Project Manager,* it is primarily not the client's decision to determine whether shift work should be used or not. However, indirect the client can influence the contractor through the allowed working times for the project, and how the work should be performed. In rail projects, when the contractor only has limited access to the railways, shift work can be "forced" by the client. The client is often than pushing the contractor to expedite some parts of the project, where they suspect a great impact on the surrounding environment. Mentioned by the *Technical Supervisor* is that "I do not believe that we will carry out a change in the industry until the industry requires us to do so, or if the client requires the change."

There are indications of economic incentives if more than one department of the company is taken into consideration, argues the *Sale and Customer Manager*. When a large corporation is vertically integrated and has divisions in several stages in the production process, economic incentives can be identified through the chain which otherwise would have been neglected. According to the *Sale and Customer Manager,* significant cost reductions can be found in the departments of Machinery Rental, Bitumen Production, and Rock Excavation. By using shift work, the Machinery Rental Company can reduce the payoff time of the machinery. The Bitumen producer has considerable costs for each time the production starts and sizeable fixed cost, which indicate shift work, could reduce the production cost by extending production hours. These cost reductions that can come from synergies in the vertical divisions are unnoticed when only one division is taken into consideration, and therefore it is vital that large companies evaluate if profits can be found in the entire value-chain.

If it lies in the client's interest that the project is finished on time or before schedule, shift work can be a useful strategy, states the *Planning Manager.* It could be that the client has upcoming projects, which are interdependent with previous projects. Then the client might be willing to pay the additional costs that come with shift work to ensure that the deadlines are held. The *Site Manager* argues that shift work might also be suitable for repetitive projects where the uncertainty is reduced, since then a function working routine could be developed.

There is also a sizeable social advantage that can come from shift work for the society as a big, which is neglected today, according to the *Technical Supervisor*. For instance, can the impact on the surrounding area a construction project entails, in term of traffic congestion and noise, be reduced by shortening the time plan. The *Technical Supervisor* further states, it is difficult to estimate the cost the construction industry cause to the surrounding area, which is the reason why it sometimes is neglected but argues that the client should consider it in a greater extent. If the shutdown time of public roads could be reduced for the third party and end-users, the public welfare could increase. To count on social benefit is something that usually is done in the early design phase of the project. An example given by the *Project Manager* is when the bonus was given to the contractor executing a renovation of a bridge, crossing a highway. For each week the project was finished earlier than the contracted time, the contractor was entitled to financial compensation. Pointed out by the *Site Manager* is that:

> *"Experiential, shift work is used when the project is not following the initial timetable, which means that a forcing of the project has to take place. Shift work is rarely a requirement from the client, which I think it needs to be before exploring a change in the construction industry. At the moment, shift work is mainly used when there is a tough deadline or when a reward to the contractor is involved."*

Collaboration between the shifts is vital to ensure success in the project, states *Construction Worker A.* There is no "one best way" to perform work in the construction industry. All employees adapt the work sequence after their preferences, like placing machinery where they think it is most suitable, which can create disputes between the shifts, especially if there is lack of insight of why decisions have been made. To prevent this, *Construction Worker C* states that an overlap between the shifts, or a written description of the work status, is used to ensure that the next shift gets sufficient information. *Construction Worker B* argues that a physical meeting provides more information than the written description, but it requires one day with overlap, which gives one extra day where no one is fully off work. This could be overcome if a written description is used and can be complemented by phone calls if necessary. The *Site Manager* adds that many changes happen every day in the construction industry. Therefore, shift work comes with a high risk of production inefficiency if the information is not passed over, which is further explained by the *Site Manager:*

> *"To make effective overlaps between the shifts, it requires synced teams. Still, it is based on the fact that it is phased in the project that has been executed and performed several times by the shift crews, and that the work is relatively monotonous."*

5.4 Social Aspects of Shift Work

At the project where *Construction worker B, Construction worker C* and *Supervisor* is working, they have two shifts that work seven days, and then a seven days rest period. Even if this shift work allows for more days off work compared to regular working hours, it is hard to take full advantage of it argues *Construction Worker C.* There are no friends or family you can socialize with before 4.00 pm the week off

work, which results in spending most of the time home alone and it is only every other weekend possible to spend time with friends and family. This view is supported by *Construction Worker B* who further states that depending on personal conditions and family situation, shift work can be more or less suitable. The *Supervisor* enhances this by stating that if one is a single parent, it is almost impossible to manage the personal life the week one is at work. The *HR Manager* also states that even if there are two parents, it could be difficult to make the family schedule come together if the parents have two different schedules. For instance, participate in children's activities or pick up and drop off them at school and spend time with the partner. The *Technical Supervisor* believes it is unlikely they would implement shift work as a standard in uncomplicated, urban projects without it being a demand from the client. The impact on the employees would be too severe, and people benefit from working at the same time as their friends and family, argues the *Technical supervisor*. The *HR Manager* also states, "Economy and time are aspects that drive shift work frightfully while the social aspects obstruct the growth of shift work in the industry." The *HR Manager* further states that "the company is not experienced in shift work; hence there may be some resistance. This leads to higher personnel costs and could eventually affect the reputation of the company."

In certain cases, shift work can have positive aspects to the social life, argues the *Site Manager*. If a project requires much traveling to get to the construction site, workers usually prefer to work long days when they are at site. This is supported by *Construction Worker B* who argues that it would be preferable to work Monday-Thursday and extend the weekend rest. Initially, seven days off work sounds good, but being off work when no one else is has its drawbacks and it is also hard to fully let go of the work states *Construction Worker C*. When there is no one to interact with during the days, it is not uncommon that you start to think about the work and issues that occur and how it might be resolved.

If one knows that shift work will be used in a project, it is possible to prepare the routines, which is harder when shift work is forced into a project to meet the deadlines, argues the *Supervisor*. It was also emphasized by *Construction Worker B, Construction Worker C* and the *Supervisor* whom all were working shift at the time the interviews took place, that shift work entails a severe level of fatigue. It reaches the peak the last day of the shift and the first day off shift one are not able to do anything but sleep, an example was that deliberately leave the kids at the daycare one extra day because one is too tired to take care of them the first day after a working week.

6. Discussion

This chapter discusses the theoretical framework, the financial evaluation together with empirical findings to compare the different parts and find the decisive factors for when shift work can and could be used. The outcomes from the previous chapters will be deeply analyzed and discussed in relation to the purpose of the thesis and the research questions concerning economic, time and social aspects, initially stated. Furthermore, the discussion will lead to a model to be used for evaluating whether shift work is to be used as well as a subsequent evaluation of the implementation model's limitations.

6.1 Competitive Advantage

When the business environment is as fearsome as the *Operative Manager* describes the construction industry in Gothenburg today, it can be vital to gain a competitive advantage. Grant (2012) presented two strategies through which a company can achieve this, differentiation and cost advantage. Kim and Mauborgne (2005) argued that it is essential for a company to understand the drivers of the market to be able to create new demands. If a business model can be found, where shift work is used as a standard, it is possible to acquire new market shares through what they call blue ocean strategy, according to Kim and Mauborgne (2005). If Henry Ford had asked people what they wanted, no one would have answered an automobile but rather faster and stronger horses. Ford understood that the core of the demand was fast and reliable transportation and was therefore able to offer a new product and became market leading. A contractor can be viewed as a service provider and production time is partly the core of the demand, which makes it likely that by offering a unique service through reduced production time, a blue ocean market strategy can be achieved. This market strategy is what Grant (2012) referred to as differentiation and argued that customers might be willing to pay a premium price if the company offers a service superior to competitors on the market. In addition, if the client is willing to pay a premium price, it would reduce the risk a construction project entails the contractor. Reforming a company's work strategy can both be costly and associated with several risks. It is therefore essential that financial incentives can be identified which can constitute such large organizational investment.

Economies of learning is a cost advantage presented by Grant (2012), which is vital in the construction industry. The *Site Manager* argued that almost all knowledge of how work is performed lies with the workers and not in the process. It takes time to transfer knowledge within the organization and therefore to maintain experienced workers become a vital asset to a company's competitive advantage. Capacity Utilization and Production Techniques are likely areas that can entail a competitive advantage if they were more developed. As the *Planning Manage*r stated, the production efficiency has not developed during the last decades. Optimizing a company’s resource utilization can lead to a significant increase in revenue and reduce the construction time, especially for repetitive construction projects, and thereby increase their competitive advantage (El-Rayes & Moselhi, 2001). Furthermore, the *Operative Manager* stated that there is a need for a change in the industry toward a more efficient working environment, but is critical of achieving improvements in efficiency through shift work. This indicates that a change is requested in the industry, the question is just how. Shift work could be one possible solution, but no matter what changes the industry will implement, the mindset in the

industry has to be changed. The question is whether the mindset must change in order to shape a new industry, or will the mindset adjust after a change has taken place?

From the empirical findings, the *Operative Manager*, *Planning Manager*, and *Supervisor* all agreed there must be economic incentives that override the additional cost of shift work in order to make a change possible. In addition, they argued that today the client decides when shift work should be used in a project and if it would be used in a greater extent, it is again the client that must ask for this type of service. However, when Apple launched the iPhone, few people thought that was a product that was asked for by the customers. Nonetheless, Apple quickly become market leading in the segment premium phones, and today no one discusses if there is a demand for smartphones. Just like how Apple took over the phone market, it is possible that the demand of fast production in the construction industry has been misread and it is assumed that the client is not interested in this sort of service just because it is not used as a standard today.

There is a general mindset from the empirical findings, which is "why change a system that works today?" The statement given by the *Technical Supervisor* "I do not believe that we will carry out a change in the industry until the industry requires us to do so, or if the client demands the change", indicated that the contractor is not prepared to make a change, without support from the client. The resilience toward development is likely profoundly rooted in the organization and can come from how the core business is performed. Styhre (2012) presented a theory about the leadership style used in the construction industry, where much time is spent working ad hoc and little time goes into long-term planning. This breeds a culture where the best strategy is to quickly adapt to new demands and not focus on the long-term strategy and can explain the resilience of striving toward development. However, other research, Kadefors (1995), indicate that the view of construction industry as chaotic and ad hoc is exaggerated and argues that the industry is institutionalized and seldom bring about long term change.

The financial calculations, made on a standard project, showed that it is possible to find economic incentives, with an increased profit up to 26 percent, without bonuses from the client. It can therefore be argued that it is possible for a construction company to start use shift work in selected projects to gain market shares. However, with an industry-wide change toward shift work, there is even greater profitability to be found which is why a dissemination of the positive aspects of shift work should be of high relevance for the company. In addition to strengthening a division of a company's position on the market, a large vertically integrated company can have increased earnings in more than one stage in the value production, if a significant change in the company is accomplished. Then, there is a need for the whole company to see the benefits of co-operating in shift work. The *Sale and Customer Manager* argued that substantial incentives could be found in early stages of the value chain. It is therefore vital to fully understand the incentives strategic decisions could entail.

6.2 Challenges for Implementing Shift Work

When the construction industry deals with a high level of uncertainty in the daily operation, it makes the execution hard to plan in detail when late changes are a constant struggle. Pointed out by the *Site Manager*, it is common that the client adds

or changes the scope of the project during the construction phase and the involved parties of the project must adapt and perform in agreement with the new circumstances. In addition, the fact that it is not uncommon that the quality of the drawings is insufficient, which was highlighted by the *Technical Manager,* adds to the uncertain environment the construction companies operate in. Shift work requires an even higher level of planning, accuracy, and communication to maintain the workflow efficient, which is stated in the interview with the *Planning Manager*. Clausén and Sjödin (2008) argued that the level of uncertainty is an important factor when evaluating if shift work should be implemented in a project. The question is whether the consequences of too high uncertainty lies mainly with the client or with the contractor and if the uncertainty could be reduced through improved communication and collaboration between client and contractor? From the empirical findings, the *Site Manager* believed that late changes affect the contractor to the extent that it is no longer possible to deliver on time and according to budget. However, what is perceived as late changes from the contractor's perspective may partly be resolved with better cooperation between the parties, although the uncertainty could never entirely be eliminated, which is easier said than done. Cooperation is thereby a challenge to overcome when shift workplace even harder requirement on a functional cooperation.

In the social structure in Sweden today, it is expected that the men and women in a relationship contribute in an equal extent to the family income and both have a full time job. Harrington (2001) emphasized that shift work can in a great extent affect family and social relationship, which is likely to have a more severe impact today when both parents are working. This would indicate that shift work might complicate the everyday struggle to combine the working life and social life, which according to Costa (2003b) today presuppose of the normal working routines of the society. It would be unlikely and not desirable to reintroduce the old structure and therefore it is a challenge to implement shift work without compromise the employees´ social life in the social structure today.

An overall finding from the interviews is that companies do not review themselves and neither engage in identifying how innovation can be achieved. Today, the business environment is more of identifying barriers other parties control and from those argue why it would be challenging to implement shift work. It is not uncommon that large structural changes in a company, which implementing shift work would involve, are initially met with questioning and resistance. In the interviews, few could see the advantage of shift work and had an unfavorable view of why it should be used to a greater extent. It was however a distinct difference in opinion of the people interviewed. Interviewees at site, who would need to work inconvenient working hours, generally have a negative attitude to shift work, while those who work as a support function, and would not be affected by an implementation, have a more positive attitude to shift work. From this, it is possible to conclude that those who are negative may primarily be negative because of fear of being a part of the change. Kadefors (1995) argues that construction projects are complex and unique, and therefore would not support shift work. This could be an underlying factor to why there is a resilience toward shift work. Another conclusion is that it is more demanding to work shift and those who make decisions about an eventual implementation need to respect the stress shift work would have on the concerned

employees. In the financial analyze, the earliest shift starts at 5.00 am to the greatest extent match the collective agreement in the industry, and thereby minimize the additional labor cost. However, the chance of realizing this shift structure could be questioned, when it likely would interfere with finding motivated and experienced employees. Employees on site are the ones who personally may take the consequences of the decisions taken by employees around the project, higher in the hierarchy of the organization. It is essential to create conditions during shift work that even the one who decides on implementation may intend to accept, by understanding their situation.

The *Site Manager*, *Planning Manager*, and *Technical Manager* considered that if shift work should be used, the client must take the first step by putting a demand on the contractor. Depending on whether the client operates in the public or private sector, the incentive to change varies. For a client operating in the private sector, they might identify direct advantages by acquiring future revenues faster by using shift work. For the public sector, the incentives of shortening the time plan are to reduce the impact of the society. Regardless the sector, the *Technical Manager* stated that if shift work was to be implemented, the entire risk lies with the contractor but the client is the one with large incentive to gain. In addition, the success of the project is closely related to how well the client's organization perform and it is in the client's interest that the finished product is at the contracted standard, with or without shift work. It is however important to keep in mind that shift work is, to some extent, already used today, when the production process is speeded up to meet the deadline of the project. Introducing shift work would therefore not be an entirely new concept, which some tries to present it as. It is important to understand the drives and conditions to when shift work is suitable and the lack of research in this area is in some extent retaining development. Thereby the existing knowledge of the production process could be used to analyze and identify which areas that are bottlenecks, and areas that would require further collaboration and coordination to succeed. The *Project Manager*, representing a client, meant that they could influence the working hours for the project but at the same time points out that it is up to the contractor to decide if they can complete the project with shift work. Hence, from the contractor's perspective, one of the challenges to overcome before shift work can be used in a greater extent, is to convince the client that savings can be made for both parties with shift work.

Many of the concerns raised in the empirical finding are far from impossible to solve. It is more about not seeing possible solutions because the organization is not ready to go through a change. A common argument raised in the empirical study is because the construction industry in general is conservative and traditional, no one would appreciate a change not sought after. This mindset is somewhat confounding in a corporate development standpoint. Just because the system used works today, should not new ideas and technology innovation been invested in because of the fear of implementing something less efficient. This could indicate that the industry is aware of rising demands for efficiency improvements, but not prepared to undergo a change. The argument that the construction industry is conservative and therefore not interested in new ideas and strategies, may only be used as an easy way to reject ideas. This view can be considered a facade only withheld by the people still using this obsolete argument and thereby suppressing development.

Mentioned by the *Project Manager* is that many of the barriers related to the support functions, subcontractors and suppliers can be managed efficiently through proper planning and preparation for unpredictable events during inconvenient working hours. Either, the workflow must be adapted to when support functions and subcontractors can deliver, or these parties must adapt to the contractor and the project. The *Operative Supervisor* emphasized the importance to maintain a consistent workflow if shift work was to be implemented. The workflow must sustain, both in short-term and long-term and a well-developed work approach is then required, where there is a strategy on how to deal with both depressions and booms in the industry. The construction industry's workload goes in cycles, which means that when there is a work boom there are plenty of projects, but the human resource is scarce. In a depression, human resources are abundant but there are not enough projects to support shift work. This can be seen as the paradox of shift work, which indicates the challenges shift work faces varies depending on the market situation. As the *Sale and Customer Manager* pointed out, "would it still be beneficial with shift work in five years?" is a question that needs to be taken into consideration if making a change. As a well-established company, to create a strategy for long-term planning as well as short-term planning is of high relevance.

6.2.1 Human Resource Requirement

The concern raised by the *Site Manager* and *Operative Supervisor*, regarding it is hard to employ workers with adequate experience and skill, must be taken into consideration when evaluating the outcome shift work might entail. According to Marks, Awolusi and McKay (2016), does the construction industry already experience a higher number of workplace accidents and fatalities than other industries. It could thereby be argued that the risk of increasing this trend is substantial if workers with scarce experience are allocated to a project with shift work. The current situation, described by the *Site Manager* and *Operative Supervisor*, is partly caused by the fearsome competition between companies on the labor market. Spoken out by the *Operative Supervisor* is that the ongoing boom in the industry drains the labor market of competence, which is a part of the paradox of shift work that previously was presented. Moreover, with shift work there is a risk of losing additional competence if not being perceptive of the employees. The *Supervisor* and *Construction Worker C* intimidated a hint that the organization does not take their well-being and concerns seriously.

If people are forced into shift work, there is, according to the *HR Manager*, a considerable risk of increasing the labor turnover. This would come at a significant cost, both from losing knowledge and the time and cost it takes for new employees to learn the new procedures. It would also make the company lose their competitive advantage that comes through Economies of learning, presented by Grant (2012). In addition, there is an opposing view in the interviews toward working in shift. This can be caused by earlier experience when shift work was forced into a project to meet the deadline, resulting in high level of stress, inadequate work and safety procedures. To prevent the risk of labor turnover and loss of knowledge, it would be possible to employ a selected team, designated to only focus on projects where shift work can be performed. The employees would in this team be aware that shift work is a part of their working routine and value increased income and less working hours per week

over the regular 7.00 am – 16.00 pm working days. Also, if the employees want to work in shift, it would likely reduce the risk of grudges between the shifts and improve the collaboration and communication. However, the *Operative Supervisor* argued that a designated team, only performing shift work, requires an even flow of projects to support the expanded organization. If the production flow is lost, it would force the shift workers to non-shift projects and thereby lose the continuity.

6.2.2 Health Issues Caused by Shift Work

Increased risk of accidents and work-related injuries are pointed out by Folker and Tucker (2003) as essential risks caused by shift work. By adopting the shift structure after the theoretical framework and to the unique preconditions of the construction industry, it is possible to reduce the negative health impact shift work entails.

Both the theoretical framework and the empirical findings considered the indirect health effects as an essential part that must be taken into consideration when deciding whether to use shift work in a project or not. Knutsson (2003) pointed out that the indirect health effects can be traced to either disturbance of circadian rhythm or disturbance of social patterns, which causes stress, behavioral changes, and mental strain. Therefore, it is crucial when designing a shift structure, attention is directed to if the circadian rhythm and social patterns are disturbed, and if so to what extent. Costa (2003a) emphasized the importance of a company's ability of adjustment to employees' individual conditions to reduce the impact shift work could cause. In the empirical finding, it is evident that shift work causes additional physical and psychological strain for the workers, which can call for additional health checks for employees working in shifts.

In the empirical findings, it emphasized that the construction industry is a safety-sensitive industry with severe consequences if an accident occurs, which is supported by Marks, Awolusi and McKay (2016). Mentioned in the literature is that the risk of errors and accidents are substantially higher during the night shift, but findings from the interviews indicate that working during evenings also have an evident impact of the workers' safety. Li and Poon (2013;2014) stated that accidents are caused by several interlinked factors which together lead up to the accident. If shift work is used, this interlinked domino effect might elevate the risk of accidents if decisions and actions in the first shift are not communicated properly to the second shift. Figure 2 also shows that the length of the shift and hours between breaks is of relevance when designing a shift. The relative risks increase with the length of the shift, which makes the 7/7a and 7/7b shift less suitable for the construction industry. This is also supported by the *Supervisor, Construction Worker B* and *Construction Worker C*, who currently works in a 7/7 shift system. They all agreed that the impact of this shift structure could be noticed by increased fatigue, which can cause negligence and increase the risk of accidents and socially through less interaction with friends and family. Some of the interviewed persons from the 7/7 shift system claim that they are not satisfied with the situation of the shift system. Having individuals in the team who are dissatisfied with their work situation might affect the employees' motivation, and in the worst case, the company risk to lose significant employees. In the long run, to ensure contingency of shift work, there is a need for clear guidelines, routines, and structure for all involved in projects and their rights and obligations to be able to reduce misunderstandings and dissatisfaction at the workplace. If looking at the

other types of shifts, presented in the financial evaluation together with the theory presented by Folkard and Tucker (2003), the shift systems with least hours per shift is best in safety perspective. Thereby, if not considering the economic aspects, the 8/6a and 8/6b are the best options. However, in a combination of being both the best option in the economic calculations of the studied project and having less reduced working time for the second shift, which also is beneficial in term of health and safety, the 8/7b is the best shift structure for the studied project.

6.2.3 Impact on Society

Noise is probably the most common argument in the empirical findings to why shift work is not suitable in the construction industry, which is pointed out by the *Operative Supervisor, HR Manager, Planning Manager, Site Manager* and *Construction Worker B* as a precondition that must be taken into consideration for all projects. However, when it comes to large infrastructure projects in urban areas, such as Västlänken, the impact on transportation and movability might cause more severe impact to the society than the construction noise. Traffic is usually highly exposed to construction projects, with the result of extensive congestion, affecting the air quality and contributing with additional noise. Gilchrist and Allouche (2005) argued that the additional cost to the society might exceed the direct cost of production. The *Planning Manager* also addressed that the cost of production has increased without any indication of efficiency improvement. It can therefore be argued it is of importance that the construction industry questions itself and evaluate how improvements can be achieved. As there are many locations where shift work is not a suitable strategy, there are locations where shift work could be applied. In addition, measures can be taken to reduce the noise impact when the preconditions require actions, such as temporary sound barriers or build-in noise-generating activities.

It is essential to underline that this argumentation does not try to diminish the importance of the noise regulation. Without the legislation, construction in an urban environment could cause sleep and mental disturbance on a large scale. On the contrary, as the *Planning Manager* pointed out, it is more about the lack of interest in finding new solutions and possibilities that retain development. It is vital to view the cost of a project to the impact on the surrounding environment it entails. If public clients would consider additional cost, such as traffic delays, health impact, the economic impact to local business when evaluating the production time related to the cost of the project in a greater extent, it is not unlikely shift work would become a favorable strategy.

6.3 Model of Implementation

The developed model aims to assist the evaluation of whether or not shift work can be a useful strategy, in the early planning phase of projects. Shown in the financial evaluation is that there are incentives for the company to increase the use of shift work, but the shift structure is highly dependent on the circumstances of each project. Since the preconditions are unique for all projects, like location, organization, and level of fixed cost, it is difficult to get an overshadowing implementation of shift work. Thereby, The Model should be used as an indicator and an initial evaluation to check whether the necessary requirements for shift work are met and then check what *should* be met before an implementation. If the necessary requirements are met,

and other obstacles can be solved, a more in-depth analysis of the economy should be conducted. This by going through different types of shift structures to find the most suitable and profitable structure for the specific project.

6.3.1 Model

The Model is structured with two requirements that must be met if shift work should be considered. These are followed by several criteria that should be fulfilled to enable shift work but can be disregarded if it is believed there are substantial incentives to be found. If these criteria are disregarded, it will affect the organization through immense strain to deliver the project after the contracted budget and time plan.

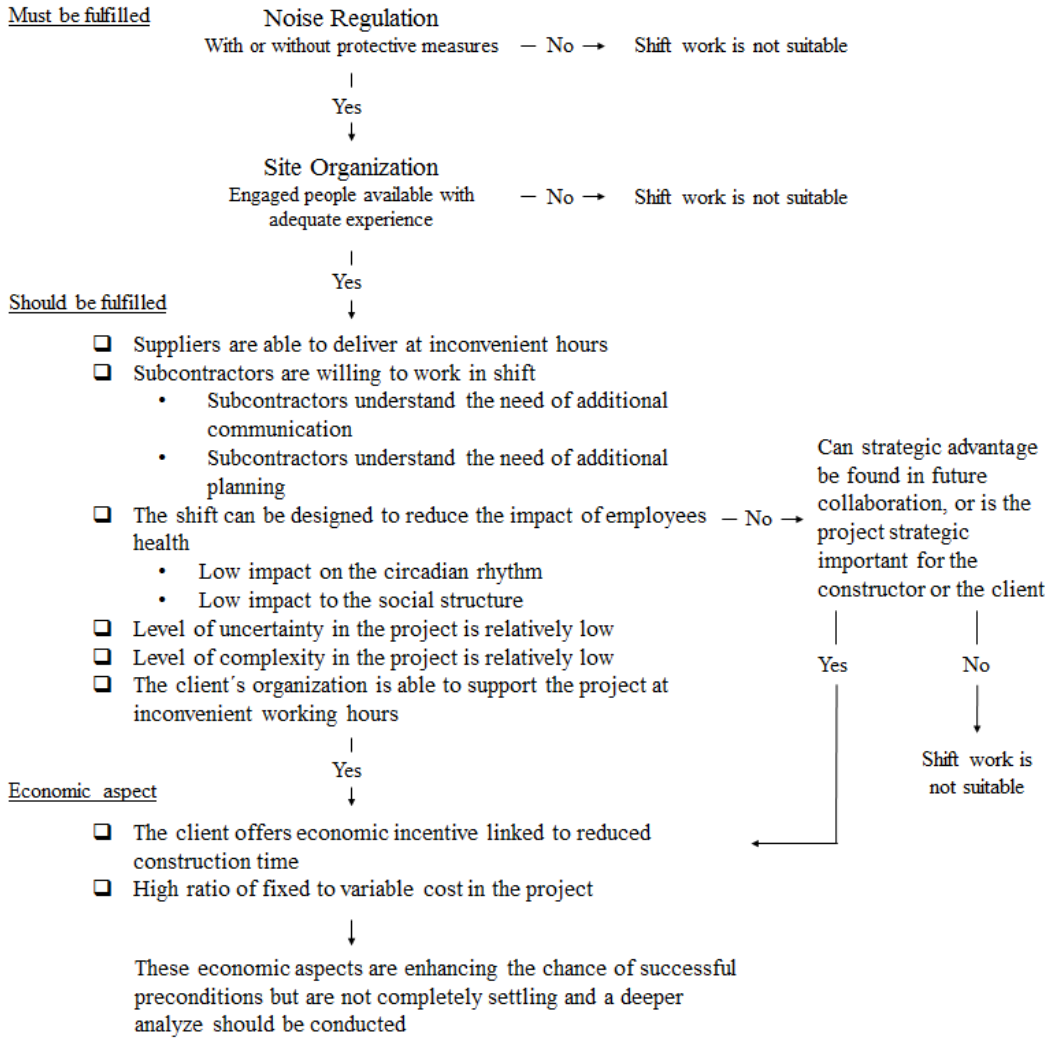


Figure 4: Model of implementation.

6.3.2 Evaluation of the Model's Deficiencies and Strengths

Many of the criteria require more in-depth investigation which also requires extra effort in the early phase of the project. Hence, if using the model frequently there is a need of creating routines for how the criteria should be investigated. The criteria are subjective and the organization thereby has to determine how the evaluation should be performed in detail to ensure that the same subjective assessment is made in different divisions of the company. Some of the criteria are harder to evaluate, for

example the level of uncertainty in the project. Firstly, different persons within an organization can have different opinions of when the uncertainty becomes too high. Secondly, what should be included in uncertainty could vary, like number of companies involved in the construction project, if special knowledge is required or the quality and accuracy of the preconditions, which must be considered in the tendering process Furthermore, the estimation of what consequences a risk would entail if it occurs is just as hard to estimate, concerning delays and additional cost. The lack of consistent, measurable parameters makes the model as it is inconclusive and must be further developed to be a reliant tool.

The Model is based on that the criteria will be fulfilled during the whole project. In some cases, the criteria might only be met in most parts of the project. Then it might be profitability found in using shift work in those parts of the project that can meet the requirements and criteria, which this model not will expose. The Model address the most critical factors, according to the theory and empirical findings. The factors are unranked and not weighted of importance which could cause severe consequences when there are significant variations in the preconditions of projects. If the subcontractors' budget represents 50 percent of the total budget in one project, the factor "subcontractors are willing to work in a shift" becomes utterly essential, compared to a project where the subcontractors' budget only represent 10 percent of the project budget.

In the financial evaluation, a correlation between value adding hours and additional OB hours for when a shift structure was profitable or not. The profitable 8/7b and 8/8b had a ratio of Value adding hours/Average OB Hours at 0.76 respective 0.79, and the other structures had a ratio of 0.74 or less. This ratio can be used when evaluating if shift work can be suitable, and the following formula used as an indication of the profitability of the shift.

$$\textit{Value adding Hours/Average OB Hours} > 0.75$$

In addition to this formula, the ratio of fixed to variable costs in a project is affecting how much the cost can be reduced when implementing shift work. The higher level of fixed cost a project experience, the more likely it is that shift work becomes a suitable strategy. Another vital factor that undoubtedly influences the risk and motivation toward use shift work in a project is if the client adds additional incentives if the project is finished before the agreed deadline.

7. Conclusion

It has been identified that shift work can cause severe risk of injuries and have an impact on the workers' social life, resulting in serious health impacts. However, there are clear indications that with proper knowledge of risk management when designing shifts and by knowing how the drivers of risk are interlinked, it is possible to regulate the impact shift work would involve. It is clear that shift work is not for everyone and the risk of losing vital knowledge through increased labor turnover is a serious threat if shift work is forced into an organization which can cause a severe impact to the production capacity due to the dependence on the workers' knowledge.

That the construction industry has become more expensive without any clear signs of efficiency improvement is already becoming a substantial economic burden to the society through noise, queues, and pollution. In this thesis, it is shown that financial incentives can be found in a standard repetitive infrastructure project without additional measures, which form the conditions that enable a consistent production flow. At the same time, reduced construction time would give an incentive for both the contractors, clients as well as for the society as a whole. To offer an indulgence service of reduced time plan will likely come with a reduced impact on the surrounding society, and could provide the contractor an increased profit. This might imply that the industry quickly would like to incorporate shift work in their business strategy, but the identified resilience toward innovation and finding new solutions are likely to prevent development. The attitude and mindset are probably the most important obstacles the construction industry faces to experience an improvement in efficiency. The fact that shift work already exists in the construction industry indicate that it is not an impossible strategy but the conditions of when shift work is suitable must be identified in order to increase the applicability. In addition, there were indications in the interviews that there is a widespread pride of knowing how to perform the work the best way and resilience to share knowledge and experience with others. To make shift work possible, this attitude has to change to enable a higher level of collaboration, trust and development in the organization, resulting in a well-functioning division of responsibility reducing the pressure and workload of site managers.

It is unlikely that shift work is the one correct path toward efficiency improvement in the construction industry, especially with the apparent health and social impact shift work can cause if consideration is not taken, but there are no doubts that there is a need for change. In addition to the presented costs and savings in the financial evaluation, there might be hidden costs associated with shift work, costs which are highly dependent on the attitude and mindset of the organization which eventually could result in differentiation between shift work in theory and practice. Thereby, to recommend is to start with pilot projects to find out hidden patterns and costs that come with shift work. Today shift work often is forced into a project, sometimes ad hoc, which creates unhealthy conditions and consequences that not automatically should be compared to planned shift conditions. If construction companies continue to ignore possible advantageous development, as an example through shift work, there is a risk to be overtaken by the few companies that can see the industry's shortcomings and create a differentiated strategy.

8. Recommendations for Further Research

Decisions of when shift work is profitable or not must be taken into consideration from project to project. Since the projects differentiate from each other with volume of fixed costs, it is difficult to get an overshadowing implementation of shift work. This results in extra planning time for each project, which in turn could result in increased costs for the company, at least initially, which have not been taking into account in this master thesis and is something that should be deeply analyzed. Further, an investigation of challenges for support functions should be conducted, to ensure that they can support the project with the sufficient help during the whole execution period.

The financial evaluation is only based on one single project, therefore should similar calculations of the impact to time and budget of shift work be done to additional projects to see if economic incentives continue to emerge, which would give the result higher credibility. Also, additional interviews should be conducted, preferably over several divisions in a company and vertically and include client, subcontractors, and suppliers to a greater extent, to identify more opinions and patterns regarding shift work. When further research on long-term risk for the company has been visualized and resolved, then the implementation phase can begin which according to the interviews probably will meet high resistance. Finally, it is up to future research to use this calculations and investigation of shift work to problematize and shade this theoretical calculation into practice and to identify hidden costs that come with shift work, eventually through pilot projects.

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