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Human influence on the adoption of Lean strategy in the process industries: a case study of an Australian steel-manufacturer

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Human influence on the adoption of Lean strategy in the process industries: a case study of an Australian steel-manufacturer

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Certification

I, Irit Alony, declare that this thesis, submitted in fulfilment of the requirements for the award of Masters by Research, in the School of Information Systems & Technology (SISAT) in the Faculty of Informatics, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

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(Signature)
Irit Alony
30 June 2010

Dedication

This thesis is dedicated to my family in all its fragments.

My parents, whose genes gave me stubborness. Without this, my research would have never eventuated.

The children, Yahlie and Morgyn, who are a constant reminder of my potential to bring good to the lives of others.

My wonderful mother-in-law, Sonia Jones, who has always been there for me, no matter what I needed.

And finally, to my husband Michael, who is not only an endless source of love, support, patience, ideas, and energy, but also my inspiration and mentor for walking the paths of this world.

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Abstract

Lean strategy has become widely recognised since it was first popularised by the Japanese automobile manufacturer Toyota. However, despite its promised benefits and widespread proliferation, Lean strategy has not been extensively adopted in process industries (e.g., steel-making). This study examines an unsuccessful attempt to implement Lean strategy in a large Australian steel-manufacturing organisation, and pays particular attention to factors influencing scheduling decisions. This attention to scheduling decisions is both unique to the literature and crucial to a deeper understanding of Lean strategy enactment.

Multiple facets are involved in the complex implementation of Lean strategy, and thus this study draws on multiple academic sources. Operations-management and behavioural decision-making literatures are reviewed, to identify aspects relevant to this complex initiative. Common to both literatures is the importance of schedulers, who daily make operational decisions that directly affect strategy execution. This study develops a framework for factors influencing schedulers' decisions that affect the enactment of Lean strategy, based on a categorisation of factors: individual, task, and context-related.

Scheduling decisions often strongly depend on their context, and are sensitive to many interrelated factors. To identify these factors and provide an in-depth understanding of their influence on the enactment of Lean strategy, this study examines scheduling decisions within their natural setting, using an exploratory and descriptive approach. It employs a longitudinal and retrospective case study of a single company to

examine these issues with greater depth than possible when examining multiple companies.

Specifically, this study draws on two sets of data collection, which cover two different perspectives on scheduling. The first set retrospectively examines the implementation of Lean strategy in a steel-manufacturing business unit. This includes interviews with eight of the individuals involved in the implementation, as well as archival documents. To overcome the limitations of a retrospective study, this study examines current scheduling practices and factors that influence their alignment with Lean strategy. This examination is conducted through a second set of interviews, which examines current influences on scheduling practices, by interviewing eight key scheduling-team members from two different business units. In addition, documents relevant to current scheduling practices were also examined. A thematic analysis of the two sets reveals factors from three different categories (individual, task, and contextual) that support or impede Lean scheduling practices.

Findings show schedulers are critical to the sustainable enactment of Lean strategy. Schedulers were found to influence the enactment of Lean strategy in two ways: (1) They facilitate cross-functional collaboration, which is necessary for Lean strategy, and (2) They have the discretion to balance and trade-off production and sales requirements. The level of alignment between this trade-off and Lean principles can sustain, or inhibit, the enactment of Lean strategy.

When examining individual factors that influence schedulers' decisions, the findings highlight the role of schedulers' interpersonal skills and intuitive decision-making. Interpersonal skills enable schedulers to enact a strategy that they find

beneficial for the business. Intuitive decision-making is influenced by two main factors that impede the enactment of Lean strategy: (1) schedulers' attitude towards Lean practices, and (2) emotions the schedulers expect as a result of following traditional practices versus Lean practices.

While schedulers are directly responsible for making decisions that align with Lean strategy, this study identifies several contextual and task-related factors that can also impede or support this alignment. These factors include assumptions shared amongst organisational members concerning the source of business success, the way to successfully address customer demand, the role of kanbans, the way to achieve high utilisation, and the length of lead times. The study extends existing literature on Lean strategy, by identifying factors that have the power to impede its adoption in the steel industry, and emphasises the important role schedulers play in sustaining alignment.

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List of abbreviations

BDM	Behavioural Decision-making
DOI	Days of Inventory
EUT	Expected Utility Theory
NDM	Naturalistic Decision-making
PT	Prospect Theory
Q	Question
RPD	Recognition-Primed Decision
RSQ	Research Sub-Question
SCV	Supply Chain Velocity
WIP	Work-in-Process

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Chapter 1 Introduction

The effectiveness of a company's strategy is critical to its ultimate success or failure (Thompson, Strickland & Gamble 2008). Aligning daily operations with the strategy can determine whether it is successfully and effectively enacted (Voss, C. A., Åhlström & Blackmon 1997). Therefore, business success relies not just on the *selection* of a strategy but also on its *execution* to ensure customer satisfaction and optimal performance. Strategy execution and sustainability often depends critically on the staff involved in daily decisions and operations (Bird & Beechler 1995; Harris & Ogbonna 2001).

Among businesses which employ production and manufacturing supply chains, Lean strategy is widely recognised as important to business success and competitive advantage (Pfeffer 1994; MacDuffie 1995; Lewis 2000; Shah, R. & Ward 2003). Even critics admit that Lean strategy sets the standards for production and manufacturing strategies in the 21st century (Shah, R. & Ward 2007). Lean strategy has been the symbol of efficiency and optimal performance since the 1980's, mainly due to its association with the automotive industry (particularly Toyota). It has been shown to outperform the traditional production model of large batches and high inventories (Boyer et al. 1997; Nakamura et al. 1998). Lean strategy has successfully enabled businesses around the world to address customer demand, while maintaining high production volume (Ohno 1988; Sohal & Egglestone 1994; Sriparavastu & Gupta 1997; White, Pearson & Wilson 1999). This strategy provides tangible benefits and performance improvements such as lower inventory levels, improved throughput times, and shortened customer-response times (White, Pearson & Wilson 1999; Fullerton & McWatters 2001).

Paradoxically, Lean strategy enables these improvements while permitting (or in fact, *requiring*) lower inventory, contrary to traditional practices. However, not all industries have taken up this strategy to the same degree (Dennis & Meredith 2000). Discrete industries, the original setting in which Lean strategy was developed (Holweg 2007), have been more successful than process industries at reducing waste and inventory levels (Schonberger 1982; Dennis & Meredith 2000; Abdullah & Rajgopal 2003). These industries routinely handle discrete parts both as input and as finished product. In contrast, process industries add value by modifying the physical or chemical properties of materials. These industries lag behind discrete industries in the uptake of Lean strategy (Dennis & Meredith 2000; Abdullah & Rajgopal 2003; Belvedere & Grando 2005).

The difference in uptake between the two industry sectors suggests that process industries are innately unsuitable for the successful adoption of Lean strategy, but this is not the case. The steel industry is an example of a process industry that is a potential candidate for the adoption of Lean strategy. This industry is characterised by high volume and relatively predictable demand, two traits that can make it a good candidate for the benefits of Lean strategy (Christopher 2000; Christopher & Towill 2002). Indeed, several reports of successful adoptions and executions of Lean strategy in the steel industry exist, (Dhandapani, Potter & Naim 2004; Harrison 2005; Abdulmalek & Rajgopal 2007; Storck & Lindberg 2007), suggesting that the steel industry can adopt at least some of its aspects. These reports, however, do not explain why Lean strategy is not accepted more widely in process industries, such as the steel-making, chemical, paper, and oil industries.

Examining a case where Lean strategy was rejected in a process industry can shed light on the factors that may impede its wider adoption amongst similar industries. Failed projects are a potential source of valuable lessons that can provide insight for future change attempts (Sauer 1999; Cannon & Edmondson 2005; Bartis & Mitev 2008). An examination of failed change projects reveals obstacles and hindrances that could not have been predicted (Williams et al. 2005). The obstacles often stem from organisational complexities and contextual interrelationships, and are thus contingent on variables specific to the organisational and industrial context.

This study reports a case of an implementation of Lean strategy in a steel-manufacturing organisation, which, despite initial benefits, was not sustained. Studying the eventual rejection of Lean strategy in this organisation provides a unique opportunity to identify factors that can be responsible for the low uptake of Lean strategy in process industries. This research, therefore, takes an inductive approach in order to answer the question (summarised in Table 1.2): *What impedes the enactment of Lean strategy in process industries, such as steel manufacturing?*

1.1 Key principles of Lean strategy

Lean strategy is driven by three main principles that affect daily production operations: (1) *value*, (2) *paced production*, and (3) *continuous improvement.* A brief definition of each principle and its impact on daily operational decisions is presented next, and summarised in Table 1.1 below.

(1) Value –Lean strategy takes a customer-centric view of value creation, and determines the value of the final product based on what the customer is willing to pay for it (Ohno 1988). This is in contrast to traditional production and operational strategy,

which takes a cost-centric view and determines product value and price based on production costs (Aitken et al. 2005). These different perspectives also mean different priorities. Traditional strategy prioritises economies of scale to reduce costs-per-unit, and thus prefers large batches. Lean strategy, in contrast, does not seek scale economies. Rather, it emphasises quick delivery, which is seen as an important source of value; Lean strategy prioritises small batches that reduce overall production lead time (Womack & Jones 2003).

(2) Paced production – Lean strategy aims to optimise production over the entire business (Ohno 1988; Rother & Shook 2003; Womack & Jones 2003). This is in contrast to traditional production strategy, where each production unit seeks to optimise its own operations (Schonberger 2007; Taylor & Taylor 2008). The difference in the scope for optimisation leads to a different view of product flow. Lean strategy aims for a continuous flow of product (Huang & Kusiak 1996; Sewell & Wilkinson 2001). To achieve this continuous flow, Lean strategy requires that production is controlled and paced along the entire supply chain, by scheduling small and standardised batches (Rother & Shook 2003; Hopp & Spearman 2004). This preference for small batches and paced production is contrary to the traditional focus on local optimisation of the performance of each unit, which inevitably leads to production in large batches (Simchi-Levi, Kaminsky & Simchi-Levi 2003).

To control and pace production, Lean strategy typically uses a mechanism called "kanban" (Ohno 1988). Kanbans indicate the level of intermediate product between two production units (Huang & Kusiak 1996). When these levels reach a permitted maximum, the kanban is considered "full" and indicates that the supplying unit should

stop production. Adherence to kanbans is central to the enactment of Lean strategy (Hopp & Spearman 2004), whereas in the traditional strategy, kanbans can be an impediment to the localised performance of individual units.

(3) Continuous improvement – Lean strategy places a strong emphasis on striving for perfection, and views production operations as an inseparable part of this pursuit (Ohno 1988). Lean strategy requires that processes are constantly re-examined in search of imperfections, and relies on low inventory levels to expose these imperfections (Womack & Jones 2003). This is as opposed to the traditional strategy, which episodically addresses problems and improvements, but does not necessarily seek a fundamental solution. The traditional strategy is happy to rely on inventory levels to buffer potential problems.

Lean strategy identifies imperfections through evidence of excess raw material, overproduction (i.e., producing more than ordered), unnecessary transportation, lengthy setups, overselling (i.e., selling more than can be produced), defects, unwarranted labour, complex solutions, unproductive use of energy, ineffective space and layout, or unnecessary motion (Ohno 1988; Monden 1994; Womack & Jones 2003; Taylor & Taylor 2008). To expose such sources of imperfection, Lean strategy relies on low levels of intermediate product inventory, also termed "work-in-process" (WIP). This is in contrast to the traditional strategy, which often results in high levels of WIP.

Table 1.1 summarises the differences between principles of Lean and traditional strategy, along with their practical implications.

Table 1.1: Principles of Lean and traditional strategies		
Principle	**Lean Strategy**	**Traditional Strategy**
Value	Customer-centric	Cost-centric
Practical emphasis	Quick delivery	Scale economies
Optimisation	Overall	Localised
Practical emphasis	▪ Small batches ▪ Paced production (kanbans)	▪ Large batches ▪ Localised optimisations
Overcoming problems	Continuous improvement	Episodic improvement
Practical emphasis	Low WIP exposes problems	High WIP buffers problems

The requirement to strictly maintain low WIP levels throughout the supply chain of a business is central to sustaining Lean strategy (Hopp & Spearman 2004). Reduced supports the achievement of Lean principles: low WIP levels enforce paced production, expose imperfections for improvement, and force value generation in ways that do not rely on scale economies.

WIP levels, like other inventory levels, are not controlled directly (Sterman 1989), but result from indirect daily operational decisions regarding batch sizes, number of changeovers, and aspired inventory levels. These decisions are routinely addressed by schedulers (MacCarthy & Wilson 2001), often operating in teams that include planners and controllers (McKay & Wiers 2003). Consequently, the role and impact of schedulers on the enactment of Lean strategy warrants discussion.

1.2 The impact of schedulers' decisions on Lean strategy

Schedulers are responsible for bridging and synchronising production capabilities and customer demand (McKay & Wiers 1999; Jackson, Wilson & MacCarthy 2004). They regularly balance and trade-off conflicting requirements of

timely delivery and capacity utilisation (Cegarra 2008). When schedulers prioritise these requirements in alignment with Lean strategy, the strategy is successfully executed (van der Krogt et al.). Therefore, the enactment of Lean strategy depends on the way schedulers prioritise and trade-off conflicting requirements (Baker & Scudder 1990).

Previous studies of schedulers identify their importance to operational activities and business financial performance (Fransoo & Rutten 1994; Jackson, Wilson & MacCarthy 2004; Berglund & Karltun 2007; Berglund & Guinery 2008). Schedulers have been described as influencers and negotiators, problem anticipators and solvers, and information nodes (Jackson, Wilson & MacCarthy 2004; Berglund & Karltun 2007). However, the critical role that schedulers play in the adoption of Lean strategy has not previously been highlighted. Schedulers were predominantly studied in stable operational environments, that is, where new strategy implementations are not underway (Fransoo & Rutten 1994; MacCarthy & Wilson 2001; Jackson, Wilson & MacCarthy 2004), and the link to strategy adoption has not been made explicitly. This study, therefore, extends existing literature by examining the supporting or impeding impact of schedulers on the enactment and sustainability of Lean strategy in the steel industry. This raises the first research sub-question (summarised in Table 1.2):

RSQ1: What role do schedulers in the steel industry play in the enactment of Lean strategy, and how does it compare with schedulers' previously described roles?

Since schedulers' daily decisions on priorities affect the sustainability of Lean strategy, it is important to understand what factors might influence their decision-making. Previous studies of schedulers have identified that they often rely on

behavioural decision-making strategies (MacCarthy & Wilson 2001; Cegarra 2008), which are typically sensitive to a myriad of factors (Hogarth 1987; Payne, Bettman & Johnson 1993; Mellers, Schwartz & Cooke 1998; Kahneman 2003). A major contribution of this study is to draw on behavioural decision-making literature to develop a framework for scheduling decisions. Therefore, an introduction to behavioural decision-making and its relevance to prioritisation in scheduling decisions is warranted.

1.3 Behavioural decision-making and scheduling

When seeking to optimise business activities, schedulers draw on many considerations, such as processing times, setup sequences, and product characteristics (Baker & Trietsch 2009). In addition, schedulers' decisions take into account factors that are often dynamic and interrelated, and depend on situational constraints. For example, schedulers need to consider the day of the month and week, the time of the day, the individuals working on the shift, the transportation means available, and many other factors (Higgins 1996; Stoop & Wiers 1996; McKay & Wiers 1999). Humans find it difficult to address such complex daily decisions which involve multiple and interrelated factors by using purely rational or analytical decision-making strategies (Simon 1979; Klein, G. A. 1998; Gigerenzer & Selten 2001; Kahneman 2003).

The limitations of analytical decision-making in describing human decisions are well documented (Simon 1976; Hogarth 1987; Carter, Kaufmann & Michel 2007). Analytical decision-making requires extensive and clear knowledge of the problem and its environment. The decision-maker's preferences need to be stable, organised, and ranked. Expected Utility Theory (EUT), which is the underlying theory of most

economic models, makes these assumptions, and predicts that after comparing and ranking the alternatives, the decision-maker will select that which provides the greatest value (Simon 1955; Kahneman 2003). However, ample evidence of decision-making in organisations indicates that these conditions are rarely met (see Shafir & LeBoeuf 2002 for a full review): the decision-maker's knowledge of the problem and its environment is often incomplete or uncertain. In addition, decision preferences are often constructed during the search for information. Finally, bounded rationality helps decision-makers address the limitations of processing capacity in terms of attention and time. These limitations apply to scheduling decisions: schedulers are often not aware of future events, such as orders, breakdowns, or logistics opportunities, and therefore have to make decisions based on incomplete or uncertain information. Schedulers, like other proficient decision-makers, construct their preferred courses of actions as they investigate existing conditions (MacCarthy & Wilson 2001; Jackson, Wilson & MacCarthy 2004). Finally, facing increased complexity, workload, and time pressure, schedulers resort to routine actions in attempt to reduce their cognitive load, rather than seek optimal solutions through varying their actions (Fransoo & Wiers 2006).

When the examination of each alternative comes at the expense of the examination of another, decision-makers do not necessarily seek optimal solutions. In contrast, Naturalistic Decision-making (NDM) asserts that they are often content with "satisficing" decisions (Klein, G. A. 1993; Lipshitz et al. 2001). That is, decisions resulting from low cognitive effort, providing satisfactory and sufficient solutions. Another violation of the optimality assumption of analytical decision-making is shown by Prospect Theory, which affirms that decision-makers often prefer the aversion of loss

and risk over maximal utility (Kahneman 2003). These deviations from optimal decision-making have inspired a body of research dealing with what is known as behavioural decision-making: decisions that are reflected in behaviours that deviate from rational choice (Simon 1955; Levy 1997).

Extant literature on human decision-making asserts that humans make decisions using two systems: (1) intuitive, and (2) rational (Epstein 1994; Kahneman 2003; Camerer, Loewenstein & Prelec 2005). This model of human decision-making is often referred to as "the Dual Processing Model". This model is supported by recent neurological findings, demonstrating that intuitive decisions and rational decisions occur in different areas in the human brain (Camerer, Loewenstein & Prelec 2005). Extant understanding of these systems is summarised by Kahneman:

> There is substantial agreement on the characteristics that distinguish the two types of cognitive processes. …The operations of [the intuitive system] are fast, automatic, effortless, associative, and often emotionally charged; they are also governed by habit, and are therefore difficult to control or modify. The operations of [the rational system] are slower, serial, effortful, and deliberately controlled; they are also relatively flexible and potentially rule-governed. … Because the overall capacity for mental effort is limited, effortful processes tend to disrupt each other, whereas effortless processes neither cause nor suffer much interference when combined with other tasks. (2003, p. 1451)

The intuitive system is thus very powerful – quick, effortless, and not easily distracted. This system, however, has its limitations: it cannot be easily modified to comply with new strategies, and it is highly sensitive to a wide variety of factors (Payne, Bettman & Johnson 1993). These factors influence the decision and often leads to biases and errors (Hogarth 1987; Payne, Bettman & Johnson 1993; Kahneman 2003). The two systems do not operate separately; rather, analytical decision-making harmoniously co-exists with intuitive decision-making (Epstein 1994; Sinclair & Ashkanasy 2005), and

decisions in most cases result from the influence of both systems. This work suggests that the intuitive system is an integral part of decision-making, even if the decisions seem to pertain to a more rational domain.

Similarly, research on schedulers' decision-making indicates that schedulers do not rely solely on analytical strategies in order to perform their role (MacCarthy & Wilson 2001; Jackson, Wilson & MacCarthy 2004). Rather, schedulers learn through experience, and draw on that experience when making their decisions. This type of decision-making, which relies on experience-based intuition and heuristics, is in line with behavioural decision-making (Cegarra 2008). Factors that influence behavioural decision-making are therefore relevant to scheduling decision-making.

Applying recent developments in behavioural decision-making studies to scheduling decisions enables a better understanding of the factors that can support, or impede, the adoption of Lean strategy by schedulers. In turn, this understanding of factors that influence schedulers' enactment (or rejection) of Lean strategy can shed light on the reasons behind the low uptake of this strategy in process industries. Therefore, this thesis examines factors that influence schedulers to make decisions that support or impede the enactment of Lean strategy.

The behavioural decision-making literature describes three categories of factors that influence human decisions: individual, task, and context (Payne, Bettman & Johnson 1993; Mantel, Tatikonda & Liao 2006). The "individual" category includes characteristics relating to the person making the decision, including his or her motivation in making the decision, previous experience, and capabilities. The "task" category includes characteristics of the problem addressed, such as task content domain (Weber &

Johnson 2009), information mode (Hogarth 1987; Bar-Hillel 1990; Carter, Kaufmann & Michel 2007), and time availability (Gilbert 1991). Finally, the "context" category includes characteristics relating to the conditions within which the decision is made: events surrounding the decision (Kahneman & Lovallo 1993; Kahneman 2003), and the need to justify the decision to others (Simonson 1989). The current research adopts this categorisation of factors as a framework for studying scheduling decisions. In order to identify and understand the factors that influence the enactment of Lean scheduling decisions, this research develops a framework which integrates aspects from both analytical and intuitive decisions making, and examines how these factors support or impede the adoption of Lean strategy. The development of this framework and the examination of these factors' influence is reflected in the second research sub-question (summarised in Table 1.2):

RSQ2 – What factors – individual, task, and contextual - support or impede the adoption of Lean scheduling practices in the steel industry, and how do they influence scheduling decisions?

Among contextual factors influencing schedulers, attention is paid to the influence of organisational culture. Organisational culture can be an impediment to change, if it reinforces and stabilises existing norms and practices (Kotter 1996; Cameron & Quinn 1999; Yauch & Steudel 2002). The broad and abstract nature of literature on organisational culture renders it difficult to identify of the factors that are specific to the adoption of Lean strategy in the steel industry. Although this thesis does not focus on organisational culture, the centrality of organisational culture to successful

strategy implementation warrants a brief discussion on how it affects the adoption of Lean strategy.

1.4 Scheduling practices and organisational culture

It is widely acknowledged that organisational culture influences human decisions in organisations (Deal & Kennedy 1982; Schein 1992; Trice & Beyer 1993; MacDuffie 1995; Alvesson 2002; Schein 2004; Hofstede 2005). While there is no agreed definition of organisational culture in the literature (Alvesson 2002), many researchers (O'Reilly, Chatman & Caldwell 1991; Quinn & Spreitzer 1991; Schein 1992; Alvesson 2002; Yauch & Steudel 2002) agree that:

(1) Organisational culture is shared by the organisational members

(2) Organisational culture dictates members' behaviour

(3) Organisational culture forms over time and shared history, and

(4) Organisational culture is difficult to explicate into words.

This view, however, does not provide a pragmatic understanding of how organisational culture influences practical behaviours that support or impede the adoption of Lean strategy. In order to gain an understanding of the influence of organisational culture on the adoption of Lean strategy, this study examines assumptions shared amongst organisational members that affect scheduling decisions.

Shared assumptions about "the nature of truth, time, space, human nature, and human relationships" guide individuals' visible behaviours (Schein 2004, p. 85). However, the adoption of Lean strategy requires changes in assumptions that are less abstract and more practical: the nature of value and business success, the way to achieve high production volume, and length of production lead time. These assumptions are

likely to guide scheduling practices such as determining batch sizes and changeover numbers, and affect resulting inventory levels, and the overall enactment of Lean strategy. These assumptions are a part of the organisational culture, as according to Schein's definition, "culture is pervasive and ultimately embraces everything that a group is concerned about and must deal with" (Schein 2004, p. 85). This study therefore identifies specific assumptions relevant to the adoption of Lean scheduling practices, and how they are reflected in specific common practices. The study also identifies how these common practices affect scheduling decisions. The last research sub-question therefore seeks to identify these assumptions (summarised in Table 1.2):

RSQ3: What shared organisational assumptions support or impede the adoption of Lean scheduling practices in the steel industry, and how are they reflected in common practices?

Table 1.2: Summary of research questions

General Research Question	**What impedes the successful and sustainable adoption of Lean strategy in the steel industry?**
Sub-Question 1	What role do schedulers in the steel industry play in the enactment of Lean strategy, and how does it compare with schedulers' previously described roles?
Sub-Question 2	What factors – individual, task, and contextual – support or impede the adoption of Lean scheduling practices in the steel industry, and how do they influence scheduling decisions?
Sub-Question 3	What shared organisational assumptions support or impede the adoption of Lean scheduling practices in the steel industry, and how are they reflected in common practices?

1.5 Research justification

This study has theoretical and managerial implications. From a theoretical perspective, this study addresses a gap in operations-management literature. While the

literature has begun to examine human aspects that are relevant to the adoption of Lean strategy, it has not examined aspects that are simultaneously (a) unique to process industries, and, more specifically, the steel industry, (b) relevant to scheduling, and (c) related to human decision-making. This research examines a case study that simultaneously addresses all these aspects, and thereby provides an important extension to current theory.

From a managerial perspective, this study addresses the reasons sought by researchers (Dennis & Meredith 2000) for the low uptake of Lean strategy in process industries. Process industries can benefit immensely from adopting Lean strategy, as they typically hold high levels of WIP, have extensive lead times, and suffer from low material efficiency (i.e., little raw material ends up as finished product) (Shah, N. 2005). A reduction of inventory and WIP levels provides direct financial benefits, as the cost of holding inventory is the single highest cost in the supply chain, adding up to 50% of total costs (Lancioni 2000). In addition, a reduction of WIP levels reduces the time required to process and deliver a product (i.e., production lead time), and serves to expose quality problems.

It has been suggested that the reason behind this low uptake is the conservative culture of process industries, biasing managers' decisions against Lean practices (Shaw et al. 2005). However, this claim was not supported by evidence that process industries are more conservative than discrete industries. In addition, no description of how this conservative culture impedes Lean practices was provided. This study, however, examines the cultural elements that have impeded the proliferation of Lean strategy in process industries.

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Chapter 2 Literature review

There is no single body of literature that addresses the research questions posed by this study. The adoption of Lean strategy is multifaceted, and involves individual and organisational aspects of scheduling processes, decision-making, and strategy implementation (Shah, R. & Ward 2003; Womack & Jones 2003). Addressing such a complex question requires a broad approach.

This chapter reviews three major bodies of literature. The first defines and examines the role of schedulers, defines their role, and addresses the conditions that surround them. The second examines behavioural decision-making literature, and develops a framework for production-scheduling decisions. This framework includes individual-related, task-related, and context-related aspects, thus addressing both analytical and behavioural aspects guiding scheduling decisions. The third examines human aspects relevant to the adoption of Lean manufacturing in discrete industries, identifying aspects to consider in process industries as well.

2.1 Schedulers and scheduling decisions

Despite schedulers' centrality and importance to production organisations, literature describing them in practice is relatively scarce (Jackson, Wilson & MacCarthy 2004; Berglund & Karltun 2007). However, these studies of schedulers concur that the human contribution of schedulers is essential and extends beyond mere sequencing (i.e., pure "scheduling"). This section describes this contribution and provides an understanding of how scheduling is performed in practice.

Scheduling encompasses three distinct functions: planning, scheduling, and controlling, each is responsible for a different aspect of the schedule. Section 2.1.1

describes these functions and the tasks they comprise. Section 2.1.2 describes the roles schedulers perform that extend their sequencing activities: information node, problem anticipator and solver, as well as an interpersonal role that involves negotiation and influencing other parties in the development and enactment of the production schedule.

2.1.1 The scheduling team – planning, scheduling, and controlling

Scheduling is a complex activity, requiring the integration of human and computerised input and decisions (McKay & Wiers 2003; Fransoo & Wiers 2006). Schedulers operate as part of a team comprising three inter-dependent functions: planning, scheduling, and controlling (or dispatching), as illustrated in Figure 2.1. While the three functions operate in concert, they are distinguished by different time horizons and pressures, autonomy of decision-making, and information availability. A description of these functions and their task characteristics is drawn from McKay and Wiers (2003), a rare example of a study conducted in a discrete industry sector.

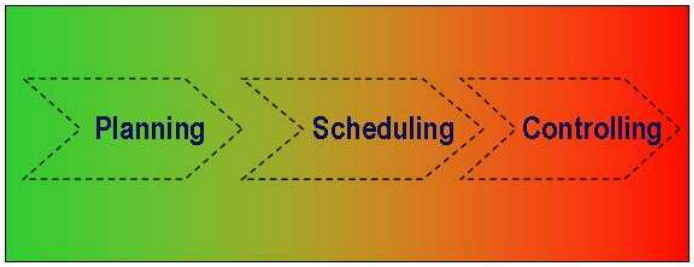

Figure 2.1: Scheduling functions and levels

Planners

Planners are concerned with the longest time horizons in the decision-making process. They focus on an aggregated level of production, grouping similar products into "buckets" that need to be produced according to a distant horizon (i.e., months, quarters, or years). Planners therefore do not operate under high time pressure; however,

they are expected to produce multiple planning scenarios quickly and accurately. Planners' work is mostly proactive, as they are expected to set future production targets.

Planners' decisions do not have a high and immediate impact on the lower levels of the scheduling functions (i.e., scheduling and controlling), and therefore their decisions are considered to have a high degree of autonomy. In addition, planners have a high degree of information availability. They are aware of demand volume, requested products, due dates, and deliveries. They also have control over both supply and demand parameters. On the supply side, planners can negotiate additional hours, or schedule overtime. On the demand side, they can balance demand with available capacity and existing inventory.

Schedulers

Schedulers are concerned with a shorter time horizon, typically around one week. They are therefore under greater pressure than planners, since their decisions are subjected to greater uncertainty, which must be addressed in a relatively short time period. The autonomy of schedulers' decisions is limited, as they are closely linked to the decisions of controllers, and if capacity utilisation is maximal (i.e., close to 100%), scheduling decisions can affect planning decisions. This study (McKay & Wiers 2003) reports that less information is available to the scheduler than to the planner; the information aspect in scheduling tasks is further discussed in Section 2.1.2. Schedulers' decisions are both proactive, aiming to prepare a schedule for production, and reactive, addressing uncertain events and unexpected input. For example, schedulers must accommodate changes to customer orders, as well as machine breakdowns and material shortage.

Controllers

Controllers are concerned with the shortest time horizon of all functions. They are mostly reactive and are typically concerned with the next few minutes, hours, and days, and thus they are under the highest time pressure. Because of this, controllers typically do not explore options in depth. Rather, they tend to be concerned with operations continuity, and their decisions are triggered by job completion, staff problems, machine breakdown, processing duration variability, and material incompatibility. Controllers' decisions can affect scheduling decisions; however, they do not have a great impact on planning decisions, as the aggregation level of these decisions is far greater than that of the immediate decisions made by controllers. Thus controllers' decisions are moderately autonomous.

Controllers deal with detailed contextual data, such as environmental factors (e.g., weather), human aspects (e.g., the impact of holiday season on absenteeism), recent performance (e.g., performance of different shifts over the last week), and standard engineering data (e.g., material specifications and processing descriptions). In addition, controllers are typically sensitive to information floating around them, such as gossip and conversations, and have been described in at least one study as , "generally being nosey" (McKay & Wiers 2003, p. 89). However the controller does not have access to information regarding customer demand, due dates, and product volumes.

Table 2.1 summarises these differences.

Table 2.1: Differences between planners, schedulers, and controllers				
	Time horizon and pressure	**Proactive/ Reactive**	**Autonomy of decision-making**	**Information availability**
Planners	Lengthy (one month – to several years), low	Mostly proactive	High	High
Schedulers	Short (one week), high	Proactive and reactive	Low	Low
Controllers	Real-time, highest	Mostly reactive	Moderate	Low

(Source: McKay and Wiers 2003)

Although the effectiveness of the scheduling team relies on the three functions to work in concert, most descriptive studies of the scheduling team focus on schedulers. The schedulers' job is the most complex due to the need to be both proactive and reactive, and due to the involvement of the other two functions (planning and controlling). The next section examines schedulers' roles, which go beyond mere production sequencing.

2.1.2 Schedulers' roles

The core responsibility of schedulers is to provide an efficient sequence of production that addresses customer demand. However, in many cases, schedulers are also responsible for facilitating the execution of this sequence. Schedulers perform several roles that support and enable facilitation, including an information node, a problem anticipator and solver, and a negotiator and influencer.

2.1.2.1 Information node

Schedulers perform the role of an information node, which means they (1) receive up-to-date information from various sources, (2) disseminate information to the production units, and ensure that information is accessible and visible (Jackson, Wilson & MacCarthy 2004; Berglund & Karltun 2007), and (3) manipulate the information they use in order to make it fit reality. Schedulers are described as filtering information using "a range of behaviors, including … selection, smoothing out, verification, [and] interpolation" (Jackson, Wilson & MacCarthy 2004, p. 543). These behaviours demonstrate the close link between schedulers and information concerning plant operation.

Behaviours relevant to this role draw on the schedulers' expert knowledge, as well as intuition (as opposed to analytical computation). This point is further discussed in Section 2.2.

2.1.2.2 Problem anticipator and solver

Schedulers are constantly aware of the production situation. Their understanding of how potential problems can affect the execution of the schedule guides them to engage in problem prevention or minimisation of impact (McKay & Wiers 2003; Jackson, Wilson & MacCarthy 2004). Schedulers are expected to solve problems resulting from unexpected events, and to coordinate different production units (Berglund & Karltun 2007).

In some cases, schedulers engage in problem-solving for a considerable amount of their time (Berglund & Karltun 2007). Several authors noted that from an operational perspective, scheduling is a problem-solving activity, and not a sequencing activity

(McKay & Wiers 1999; Jackson, Wilson & MacCarthy 2004). Schedulers, then, use various techniques and options to handle interruptions, such as re-allocation of resources and re-arrangement of sequencing details (Fransoo & Wiers 2006). However, schedulers often need to sacrifice some goals in order to achieve others (Cegarra 2008; Guinery & MacCarthy 2009). Thus, scheduling goals are not necessarily static and clearly defined in the schedulers' mind; rather, they are contextual, situation-dependent, and constructed as the situation unfolds.

2.1.2.3 Negotiator and influencer

Schedulers expend time, effort, and attention to develop interpersonal relationships with the stakeholders involved in production, delivery, and customer service (Jackson, Wilson & MacCarthy 2004; Berglund & Karltun 2007). Such relationships facilitate the execution of the schedule, as schedulers typically do not have formal authority over these functions (Berglund & Guinery 2008). Schedulers use bargaining and favours, and rely on stakeholders' trust and respect to influence their actions (Jackson, Wilson & MacCarthy 2004). As part of this role, schedulers often engage in negotiated group decision-making, where different parties often have conflicting goals and agendas (Guinery & MacCarthy 2009).

2.1.2.4 The scheduler and a new strategy

Although the scheduling team is critical to the determination of processing sequence, batch sizes, and inventory levels, no academic study examined their adjustment to a new strategy, such as Lean strategy (Sheldon 2005). While computerised support to schedulers transitioning into Lean strategy is possible (e.g., van der Krogt et al. 2010), ultimately it is up to the human scheduler to make decisions that

either accept computerised recommendations for scheduling decisions (and thus, support Lean strategy), or reject them. This study addresses this gap by examining schedulers' role in the implementation of Lean strategy.

2.1.3 Summary

Scheduling, a complex task performed by a scheduling team, is comprised of three levels: planning, scheduling, and controlling. These levels vary in terms of time horizon and time pressure, decision autonomy, and information availability. Of these three levels, the schedulers are in charge of the most complex role due to the interrelations between their schedule and the tasks of the other two levels.

The schedulers' job goes beyond mere sequencing: schedulers are responsible for enabling the execution of the production schedule. They often do not have the formal power to carry out this responsibility, and thus influence others through relationships. Schedulers often negotiate between conflicting organisational functions, and are expected to anticipate and solve problems that can affect the production. Schedulers are also required to interpret information and balance conflicting needs and priorities. Through these roles (negotiation, problem anticipation and solving, information interpretation, and needs' prioritisation), schedulers influence the alignment of the organisation's activities with Lean principles, and can potentially affect the enactment of Lean strategy.

2.2 Behavioural decision-making and human schedulers

Decision-making cannot be ignored when attempting to understand the human aspects involved in adopting Lean strategy, as daily human decisions ultimately determine the success and sustainability of this adoption. Lean strategy relies on the support of human behaviour and decisions to sustain its effectiveness (Ohno 1988; Rother & Shook 2003). Among those human decisions, scheduling decisions are critical to the enactment of Lean principles (van der Krogt et al. 2010). Therefore, this section relates decision-making literature to scheduling decisions critical to Lean strategy.

The operations-management literature mainly treats scheduling decisions as rational, computational, and combinatorial, and as drawing on factual considerations (e.g. processing times, setup sequences, and product characteristics) in their attempt to optimise business activities (Baker & Trietsch 2009). However, the literature amply shows that when facing complex decisions (such as scheduling decisions), humans rarely rely on pure analytical decision-making, as it requires more time, effort, attentions, information, and information processing than generally available to human decision-makers (Simon 1965; Kahneman 2003), and the human scheduler in particular (MacCarthy & Wilson 2001; Cegarra 2008). Schedulers need to draw on a broad range of contextual factors, such as the day of the month and week, the time of day, the individuals working on the shift, the transportation means available, and many other factors (Higgins 1996; Stoop & Wiers 1996; McKay & Wiers 1999). In addition, some of the information used for scheduling decisions is often uncertain, and schedulers' processing capacity is often limited in terms of time and attention (MacCarthy & Wilson

2001; Cegarra 2008). These conditions limit the effectiveness and efficiency of analytical decision-making.

Humans employ different heuristics and strategies to overcome the limitations of analytical decision-making (Payne, Bettman & Johnson 1993; Payne, Bettman & Johnson 1997; Kahneman 2003; Hogarth & Karelaia 2006). These heuristics are influenced by various factors, and often lead to systematic biases in decision-making (Hogarth 1987; Kahneman 2003). This research draws on analytical and behavioural decision theories in order to identify factors that influence scheduling decisions. Before presenting the prominent factors, the rest of this section justifies the use of three bodies of research: (1) analytical decision-making, (2) an underlying framework for behavioural decision-making, and (3) factors biasing behavioural decision-making.

2.2.1 Analytical decision-making

Analytical decision-making is included in this framework for two reasons. First, scheduling decisions pertain to a rational domain (Baker & Scudder 1990; Baker & Trietsch 2009) that draws on and analyses factual considerations (Loewenstein & Lerner 2003). Second, scheduling decisions are performed in an organisational context, and organisational decisions often draw on analytical decision strategies (Keeney & Raiffa 1993; Clemen 1996).

A framework for organisational decision analysis can aid in the investigation of the analytical aspect of scheduling. This framework includes the following decision stages: defining decision objectives, defining the values and objectives of the decision-makers, identifying uncertain events during the decision process, and identifying decision consequences (Clemen 1996). Following these stages of analytical decision-

making can help organisational decision-makers get better results when addressing problems involving multiple objectives and uncertain events (Keeney & Raiffa 1993). This framework is suitable to scheduling decisions, as they are often driven by overall organisational objectives and values and are subject to uncertain events, and their consequences for the organisation are considered at the time of decision-making (McKay & Wiers 1999; MacCarthy & Wilson 2001; Jackson, Wilson & MacCarthy 2004; Cegarra 2008). These different decision elements are integrated into the overall framework used in this study, which is based on a model of behavioural decision-making developed by Payne et al. (1993).

2.2.2 A framework for behavioural decision-making

Behavioural decisions are influenced by a host of factors that can induce and reinforce systematic decision biases (Hogarth 1987; Carter, Kaufmann & Michel 2007). These factors pertain to three distinct categories: (1) individual, (2) task, and (3) context (Payne, Bettman & Johnson 1993). "Individual" factors include the characteristics of the person making the decision: their attitudes towards a decision alternative (in this case, Lean practices), their motivation for a particular, their experience, and their capabilities. "Task" factors include the characteristics of the problem addressed: structured or unstructured, familiar or new. In addition, task factors can include characteristics such as task content domain (Weber & Johnson 2009), information mode (Hogarth 1987; Bar-Hillel 1990; Carter, Kaufmann & Michel 2007), and time availability (Gilbert 1991). Finally, "context" factors include those relating to the conditions in which the decision is made: events surrounding the decision (Kahneman & Lovallo 1993; Kahneman 2003), implications of the decision (Simonson 1989), and the number of available alternatives

(Payne, Bettman & Johnson 1993). Based on this categorisation of behavioural factors, the current research develops a framework for studying scheduling decisions that support or impede the adoption of Lean strategy. The applicability of this framework to the discipline of operations management was recently supported in a study of make/buy decisions wherein a survey-based experiment confirmed the influence of behavioural factors on such decisions (Mantel, Tatikonda & Liao 2006). Research thus suggests that this framework is suitable for studying scheduling decisions.

2.2.3 Behavioural decision biases

This research also includes factors that lead to decision biases. Human decisions are influenced by various factors that lead to a long list of documented decision-making biases (Hogarth 1987). This list of biases was recently organised into a taxonomy for supply-chain decisions (Carter, Kaufmann & Michel 2007), resulting in nine groups of decision biases: availability cognition, base rate, presentation, control illusion, output evaluation, commitment, confirmatory, persistence, and reference point. These bias groups are integrated into the framework for scheduling decisions, and each bias group is categorised based on its pertinence to individual, task, or context.

Figure 2.2 presents the proposed framework for scheduling decisions. The framework considers task-related factors (decision objectives, time available, and information available), individual-related factors (the individual's attitudes, experience, capability, and motivation), and context-related factors (justifiability, organisational culture, and preceding events). The next section describes these factors and how they affect scheduling decisions (summarised in Table 2.2 at the end of the section).

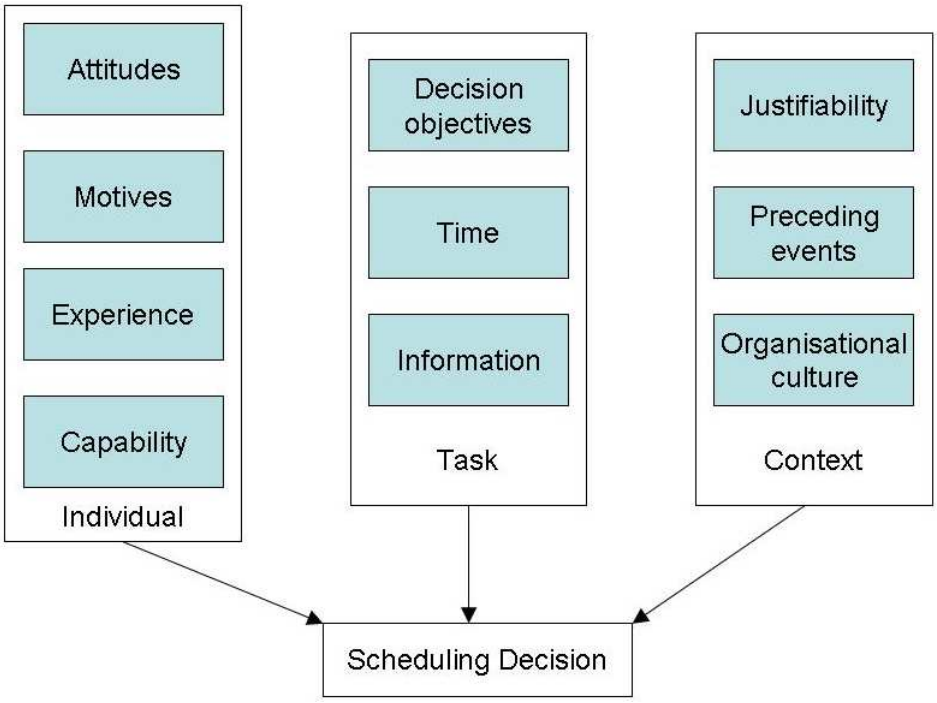

Figure 2.2: Proposed scheduling decisions-making framework

2.3 Individual (Person)

Individual decision-makers in an organisation differ in their: (1) attitudes (2) motives and goals relating to the decision, (3) experience, and (4) capabilities. These individual differences have been extensively examined in studies of human and organisational psychology, and a review of their relevance to production-scheduling decisions is warranted.

2.3.1 Attitudes

The decision-maker's attitudes have long been studied as antecedents to decisions and behaviours (Ajzen 1985; Ajzen 1991). Attitude is extensively recognised as having an evaluative role (Fishbein & Ajzen 1975; Slovic, Fischhoff & Lichtenstein 1977; Ajzen 1991). It has been suggested that "attitudes serve as heuristics, with positive attitudes invoking a favoring strategy toward an object and negative attitudes creating

disfavouring response" (Slovic et al. 2007, p. 1346). Attitude is defined as a *learned* predisposition to respond to an object in a favourable or unfavourable manner (Fishbein & Ajzen 1975). Attitudes stem from beliefs about the evaluated object (Fishbein & Ajzen 1975), and are composed of cognitive, affective, and behavioural components, are stable over time, and affect judgement, decisions, and risk behaviours (Slovic et al. 2007). The immediate and powerful effect of evaluation was illustrated in a behavioural experiment, where participants were required to push or pull a lever as fast as they could when a word appeared on a screen (Bargh 1997). Participants' speed of reaction was found to depend on the nature of the word and the action they were required to take: participants pulled the lever towards them faster when the word on the screen resulted in a positive evaluation (e.g., *cake*) than when the word resulted in a negative evaluation (e.g., *death*) (Bargh et al. 1992). Since scheduling decisions involve judgement, risks, and time constraints, the influence of attitudes is relevant.

When Lean strategy is implemented, schedulers are required to schedule smaller batches, and maintain lower inventory levels. A negative attitude towards these practices can be expected to impede their adoption. In addition, a positive attitude towards traditional practices of maintaining large batches and high inventory levels can also be expected to impede the adoption of Lean strategy.

2.3.2 Motives

Individual motives can lead to the following cognitive biases: commitment bias, confirmatory bias, and persistence bias (Carter, Kaufmann & Michel 2007). Commitment bias occurs when the decision-maker is reluctant to abandon a path dictated by previous decisions, even if this path has proven unfavourable (full review at Arkes &

Ayton 1999). As a result, the decision-maker chooses to continue or escalate a path already undertaken. An example relevant to this study would be a scheduler who approves additional maintenance on a machine, because time and effort have already been invested in fixing a quality problem caused by that machine, instead of changing over to produce a different product. The investment of resources commits the scheduler to producing a successful result, despite evidence showing this course of action is not optimal. Confirmatory bias occurs when the decision-maker has already formed a decision, and now focuses on searching for information that confirms the initial decision, restricting the search (or the impact) of disconfirming evidence (Bruner, Goodnow & Austin 1986; Karelaia 2006). For example, a production scheduler may use evidence of low reliability of a production process to confirm a decision to avoid producing the product.

The last type of bias related to motives is persistence bias, leading to the selection of an action only because it has been selected before. This bias supports "status-quo" decisions, where the decisions of the past are repeated. For example, a production scheduler may continue to produce large quantities simply because that has always been the mode of operation, regardless of whether large quantities are ordered. Additional tendencies that support adherence to status-quo decisions are discussed in Section 2.5.1.

Different decision theories attribute different motives to the decision-maker. Expected Utility Theory (EUT), which is the underlying theory of most economic models (Kahneman 2003), assumes humans seek to maximise their own wealth. In contrast, Prospect Theory demonstrates that humans seek to avoid loss (Kahneman & Tversky 1979; Kahneman 2003). This difference in motives predicts different choices

among alternatives, when there is uncertainty associated with each alternative. Contrary to EUT, Prospect Theory systematically demonstrates that humans prefer certain small gains over potential high gains, and that they prefer to take the risk of a high loss over a certain small loss (Kahneman & Tversky 1979). The fact that different motives lead to different decisions is important for predicting decisions.

The systematic human inclination to avoid risks when losses are possible can be relevant to the adoption of Lean strategy. When Lean strategy is implemented, losses associated with Lean practices should be emphasised more strongly than prospects of gains. For example, stopping production for kanban adherence involves a risk of future stock outage. The loss associated with stock outage is expected to be overweighted compared to the gains associated with the achievement of low inventory levels. The two possibilities are perceived asymmetrically in the decision-maker's mind, and thus should be addressed asymmetrically.

2.3.3 Experience

It takes little more than a browsing of the positions-vacant section in a local newspaper to recognise that employers prefer experienced professional decision-makers over novices. Experienced decision-makers display more efficiency than novices, who are prone to errors and use more resources to compute and work out a solution (Haier & Siegel 1992). A suggested explanation is that experienced decision-makers 'train' their intuitive system, by 'tagging' choices as either 'good' or 'bad', depending on the outcome and impact it had on the decision-maker's emotions (Slovic et al. 2007). According to the dual-processing model, it takes longer to train the intuitive system, which is guided by experience, as opposed to the rational, logic-based system, which is

relatively flexible in applying new rules (Kahneman 2003). This makes experienced decision-makers better at making decisions intuitively, while novices rely on more laborious and error-prone computations.

Decision-making processes of experienced individuals have been extensively studied in a stream called "Naturalistic Decision Making" (NDM). This stream of research examines how experienced decision-makers behave in realistic situations. This stream has resulted in a decision-making model called the Recognition-Primed Decision (RPD) based on field studies of experienced decision-makers from various domains, such as fire-fighting, tank platoon leaders, and design engineers (Klein, G. A. 1993). A major strength of the RPD model is that it is based on realistic observations of experienced decision-makers, and thus describes the contribution of the decision-makers' experience to the decisions.

The decision-making process described by the RPD model is different to the one described by the analytical approach (presented in Section 2.2 above). According to RPD, the decision-maker uses a mental simulation, or a "mental model", of the action and the situation at hand, to evaluate the decision. The decision is made in four stages: (1) identifying the goals that are achievable in the situation, (2) identifying cues salient to the situation, (3) forming expectations against which the situation is compared, as a check of the situations' assessment accuracy (i.e., if these expectations are violated, they serve as an indication that the assessment of the situation was incorrect), and (4) identifying a typical action to take. This is in contrast to the evaluation strategy prescribed by the analytical approach, which requires contrasting options' strengths and weaknesses.

A clear benefit to the decision-maker from using RPD strategies is the ability to initiate a course of action without evaluating all possible options. This is an important benefit for decision-makers under time pressure; however, research suggests that this benefit remains attractive even when time pressure is not present: evidence supports that engineers, even without time pressure, still use RPD strategies (Klein, G. A. 1993).

The decisions studied in developing NDM and RPD share many characteristics with the nature of scheduling in practice, and NDM has been used as a framework guiding studies of schedulers and scheduling decisions (Jackson, Wilson & MacCarthy 2004). The RPD model applies when "there is reasonable experience to draw on, when the decision maker is under time pressure, and when there is uncertainty and/or ill-defined goals" (Lipshitz et al. 2001, p. 337). This description applies to experienced schedulers, who typically draw on lengthy experience (Higgins 1996; Jackson, Wilson & MacCarthy 2004; Berglund & Karltun 2007; Berglund & Guinery 2008), and whose goals and objectives are often uncertain and conflicting, as previously discussed. While time pressure is certainly present in many scheduling situations, schedulers were found to spend a "considerable amount of time on nonformalized tasks" such as maintenance and auxiliary work tasks, indicating that time pressure is not extreme, and not constant (Jackson, Wilson & MacCarthy 2004, p. 541). However, the lack of constant time pressure alone does not eliminate RPD as an appropriate description of scheduling tasks – the RPD model was found to be used by "experienced design engineers who were not under time pressure", and who were found to rely "heavily on recognitional decision-making for difficult cases (60%)" (Klein, G. A. 1993, p. 145).

Another possible objection to the use of NDM and RPD decision-making models for scheduling is the fact that "RPD strategies are less likely to be used with highly combinatorial problems" (Lipshitz et al. 2001, p. 337). Scheduling problems are defined in operations research as highly combinatorial problems (Baker & Trietsch 2009). However, scheduling tasks in reality are not combinatorial in nature. Field studies of scheduling show that an initial schedule is generated by computerised tools, after which humans are required to address problems that prevent the implementation of this initial, computer-generated schedule in practice. In addition, schedulers are required to and deciding on priorities when interruptions prevent the virtual schedule from being fully executed (Jackson, Wilson & MacCarthy 2004; Cegarra 2008). Therefore, RPD is an appropriate theoretical representation of production-scheduling, and can be beneficial to the understanding of scheduling decision-making.

The Naturalistic Decision-making model differs from models of analytical decision-making in the following aspects:

1. Decision focus: The RPD model focuses on situation assessment, whereas analytical decision-making focuses on ranking options of response.

2. Unlike analytical decision-making, which relies on selecting an optimal action after generating options randomly (or semi-randomly), NDM shows that experienced decision-makers usually identify a reasonably good option as the first course of action.

3. While analytical decision models aim to optimise, RPD asserts that the action chosen by the decision-maker "satisfices" (Simon 1965) rather than optimises.

4. According to RPD, the decision-maker uses a mental simulation, or a "mental model" of the action and the situation to evaluate the decision, rather than contrasting options' strengths and weaknesses, as in an analytical approach.

These differences do not exclude the use of analytical decision-making for studying scheduling decisions: analytical decision-making and RPD both have their strengths, serve different functions, and can be applied to the same decision task (Klein, G. A. 1993). Thus, both models are considered in this framework for scheduling decisions.

The NDM model contends that experienced decision-makers identify salient cues in the situation at hand, and based on these cues they construct a "mental model" of it (Endsley 1997). This mental model highlights to the experienced decision-maker what critical information is still missing. The mental model is based on a "skeleton" constructed from very specific past experiences, but their details do not need to exactly match the details of the current situation. Once critical information gaps are filled, the experienced decision-maker matches a course of action to the identified situation.

The decision-making process described by NDM is expected to moderate the influence of the following biases: availability cognition, reference point, and selective perception. Availability cognition means that information more familiar to the decision-maker will be treated more favourably (Tversky & Kahneman 2003; Carter, Kaufmann & Michel 2007). Familiar information is more available for problem-solving as it is easier to search for, retrieve from memory, and imagine (Tversky & Kahneman 1974). Experienced decision-makers have a greater repertoire of mental models to draw from, as this repertoire is constructed based on a wider range of experiences and situations.

Availability therefore in fact *serves* experienced decision-makers, rather than *biases* them.

Experience can also moderate the impact of reference-point bias. To simplify judgement, humans use an initial reference point, which they later adjust; however, such adjustments have been shown to be insufficient and to bias the resulting decision (Tversky & Kahneman 1974). Experienced decision-makers are expected to make better adjustment than novices.

Another aspect of experience relates to the professional experience of the scheduler. It has been found that "people structure problems on the basis of their own experience" (Hogarth 1987, p. 216), leading to a selective-perception bias. Thus, marketing managers can see a problem as a marketing problem, whereas financial managers will examine the same problem and perceive it as a financial problem. Schedulers who come from different organisational backgrounds (i.e., customer service, engineering, or production) can handle the same decision situation with different approaches. This could bias their decisions to align with the functions of their background.

Although NDM was used in the past to inform studies of scheduling, NDM does not perfectly apply to scheduling activities. Two limitations of the RPD model reduce its applicability to production-scheduling: (1) justification and (2) other stakeholders' views. These limitations are further discussed in Section 2.5.1, as part of the decision context.

2.3.4 Capability

Complex cognitive tasks draw on capabilities that differ between individuals. As decision-makers vary in their cognitive capabilities, and in general strive to reduce cognitive load (Simon 1978), the cognitive mechanisms they select will be the ones they find easiest to employ. However, supply-chain literature views decisions such as production-scheduling as rational decisions, and provides tools such as scheduling algorithms (Brucker 2004) to optimise them; many organisations employ such tools to reduce cognitive effort (Fransoo & Wiers 2006). The task schedulers often face is then to make the adjustments necessary to the computer-generated schedule, so that it fits realistic conditions. The extent to which individual capability influences production-scheduling decisions therefore needs to be examined.

2.4 Task (Problem)

The problem, or task, comprises three factors: (1) decision objectives, (2) available time, and (3) the information available to the decision-maker. These task-oriented factors play a key role in production-scheduling decisions.

2.4.1 Decision objectives

The first step in analytical decision-making is "defining decision objectives" (Louviere 1988; Keeney & Raiffa 1993; Clemen 1996). The objectives of the problem are crucial to its definition, as they determine the aspects of the decision that need to be addressed.

Scheduling objectives and goals are typically defined by higher organisational levels, external to the scheduling team. The schedulers are responsible for translating these objectives into practice (MacCarthy & Wilson 2001; Jackson, Wilson &

MacCarthy 2004; Berglund & Karltun 2007; Berglund & Guinery 2008). In addition, scheduling goals are often dynamic, and interrelated with situational constraints. A common illustration of this point in scheduling literature is that the same schedule can be considered "good" for Monday morning, but "bad" for Friday afternoon (Higgins 1996; Stoop & Wiers 1996; McKay & Wiers 1999).

Business objectives often conflict with and contradict one another. Schedulers are required to maintain high efficiency levels, and at the same time, satisfy the demand for timely delivery. If achieving both objectives is impossible, scheduling decisions involve tradeoffs. The weight of the different objectives defines the trade-off that the scheduler is required to make. However, this weighting is not necessarily clearly defined.

Business objectives are communicated through control mechanisms such as policies, procedures, performance measures, and authority (Beamon 1998; Delbridge 1998; Cachon 1999; Mentzer 2001; Gunasekaran, Patel & McGaughey 2004). This research seeks to examine how each control mechanism contributes to the weighting that schedulers assign to each objective.

2.4.2 Time

Time available for decision-making dictates the resources dedicated to the decision task. Time pressure leads to inconsistency of judgement and superficial information processing (Hogarth 1987). For example, when little time is available, decision-makers are less likely to doubt and reject information (Gilbert 1991).

However, evidence also shows performance under time pressure improves with experience with the decision task (Payne, Bettman & Johnson 1993). This finding is

consistent with NDM, showing that experienced decision-makers are able to immediately identify a reasonable course of action, without having to analyse many alternatives. A number of researchers assert that managerial decision-making in conditions of limited time (and information) relies on intuition and emotions (Sayegh, Anthony & Perrewé 2004; Sinclair & Ashkanasy 2005). Since scheduling decisions often take place under time pressure, these aspects are expected to influence schedulers as well.

Moreover, devoting additional time to decision-making does not necessarily result in better decisions. Additional time is not necessarily used for decision refinement, but rather for decision confirmation (Karelaia 2006). Research has suggested that when more time is available for decision-making, subjects use it to confirm a decision they have already made intuitively. Confirmatory bias, discussed in Section 2.3.2 above, has an influence on decisions, through "thirst for conformation" (Bruner, Goodnow & Austin 1986).

Another time-related aspect found to influence decision-makers is the time horizon. When decision outcomes were expected in the near future, subjects were more risk-averse than when decision outcomes were expected further in the future (Payne, Bettman & Johnson 1993). This finding is relevant to the scheduling team, where each level is concerned with results that are measured (and thus, experienced) at different time horizons(McKay & Wiers 2003). Planners are often concerned with a time horizon of months, whereas schedulers are concerned with weeks, and controllers with hours and days. The difference in time horizons is expected to affect the degree of risk aversion between the levels. Since Lean strategy involves greater risk in the short term, the risk

aversion of the people in charge of decisions with immediate consequences (such as controllers) can act against the successful adoption of Lean strategy.

2.4.3 Information

Information is a critical aspect of decision-making. Since schedulers perform the role of an information node, as discussed in Section 2.1.2, it is expected that they enjoy information completeness in terms of information available at the time of the decision-making. However, information processing and interpretation can be subject to biases based on information characteristics. Two types of relevant biases are identified: base-rate bias and presentation bias (Carter, Kaufmann & Michel 2007).

Base-rate bias means that information of a general nature is ignored for the sake of more specific, less relevant, information (Bar-Hillel 1990). An example relevant to this study would be a scheduler making a decision based on a known, tangible cost, as opposed to an unknown cost: the cost of a changeover is tangible and well-known to the scheduler, whereas the "cost" of an unsatisfied customer, whose order has been delayed due to the avoidance of a changeover, is often unknown to the scheduler. This "cost" is certainly not tangible and not specific. Due to base-rate bias, the cost of a changeover will be avoided, even if in the long run, an unsatisfied customer carries a higher cost to the business.

Presentation bias is derived from elements such as information order, mode, scale or mixture, and leads to systematic bias in decision-making (Carter, Kaufmann & Michel 2007). Research shows that first and last items presented are given greater emphasis (Hogarth 1987). The mode of information has been shown to have a systematic influence on its impact (Vessey 1994). For example, decision-makers give verbal

communication more weight than written reports. Another important aspect of presentation bias is the well-known "framing effect". Evidence persistently shows that humans act on information that is framed favourably (or given a positive spin) (Kahneman & Tversky 1979), even when they find the less-favourably framed information more believable (Keren 2007).

Schedulers obtain information through various channels, including face-to-face and phone conversations, emails, and information systems. If information obtained through verbal communication systematically outweighs information obtained through written communication, this can have a consistent influence on scheduling decisions. The framing of information by certain parties can also have a systematic impact on scheduling decisions. For example, if production managers consistently frame information in a way that highlights efficiency over delivery performance, the resulting scheduling decision could be biased to favour production efficiency.

2.5 Context

Context is a difficult term to define, and indeed decision-making studies often choose to avoid it by turning to experimental studies (for example, Kahneman & Tversky 1979; Mantel, Tatikonda & Liao 2006). This study defines 'context' as the environment that surrounds a decision, including the implications relating to the decision, and the overall situation of which a scheduling decision is a part. Decision context is associated with two factors: (1) justifiability, and (2) preceding events. These two context-oriented factors of decision-making are integrated into the framework of scheduling decisions.

2.5.1 Justifiability

When decisions need to be justified to others, the decision-maker becomes sensitive to certain aspects and considerations (Simonson 1989): individuals who know their decision will be reviewed by others select an option that is less likely to be criticised. Scheduling is made in an organisational context, and therefore decisions are typically visible to others. The type of criticism decision-makers receive is expected to drive their decisions. Depending on the criticism aspects, schedulers are expected to make decision that can be justified. For example, in process manufacturing organisations, which are frequently concerned with operating costs, decisions-makers are expected to schedule an "expensive" sequence only when they can provide a reason accepted by the decision reviewers.

Justifiability was also found to lead to status-quo bias (Simonson 1992). In purchasing decisions, subjects were found to prefer a "safe" option that is easier to justify, over a risky option that may have been more favourable. Thus, since schedulers are often expected to justify their decisions, a deviation from status-quo decisions due to a new strategy may prove difficult.

Justification and the involvement of other stakeholders reduce the applicability of NDM (discussed in Section 2.3.3) to scheduling decisions. The RPD model is less applicable "in situations where justification is required, and in cases where the views of different stakeholders have to be taken into account" (Lipshitz et al. 2001, p. 337). Schedulers are not typically required to justify their decisions; however, since their decisions are made in organisational context, their results often do require justification and explanation to higher levels. For example, in a detailed case study of a

manufacturing-cell scheduler, the scheduler needed to justify the cell's performance weekly (Crawford 2001). This suggests that while a justification is not required for every action, a justification of the results is present in schedulers' minds.

The second limitation of RPD applicable to scheduling is the need to take the view of different stakeholders into account. It has been recognised that schedulers are part of a social system, and this system is inter-related with scheduling: the scheduling activity takes into account the impact on other stakeholders such as customers, production managers, and higher management (Dutton 1964; Berglund & Guinery 2008). These limitations to the applicability of NDM models to scheduling decisions suggest that scheduling decisions may follow a different process to those NDM describes. For this reason, other decision factors are considered and integrated into this study's decision-making model.

2.5.2 Preceding events

Scheduling decisions are highly contextual in the sense that they affect and are closely related to many factors concurrent with the decisions (Higgins 1996; MacCarthy & Wilson 2001; McKay & Wiers 2003; Jackson, Wilson & MacCarthy 2004). Scheduling decisions also affect the two other levels of the scheduling process, i.e., planning and controlling. Scheduling decisions are thus subject to many constraints that are interdependent and defined by timing. This can lead to two cognitive biases: recency bias and reference-point bias (Carter, Kaufmann & Michel 2007). Recent events are often more prominent in the decision-maker's mind, and thus the decision-maker tends to overweight them compared with events that have occurred in the more distant past (Carter, Kaufmann & Michel 2007). These recent events can also bias individuals'

reference-points. The reference point bias discussed in Section 2.3.3 can also be affected by short-term preceding events. One of the simplifications humans use to make decisions is to start from an initial reference point, and gradually adjust it to make a decision (Tversky & Kahneman 1974). This adjustment has been shown to be often insufficient, introducing a bias into scheduling decisions. For example, schedulers may overproduce after a recent stock outage.

2.5.3 Organisational culture

In a broader sense, the context of scheduling decisions relates to the culture of the organisation in which they are performed (Berthon, Pitt & Ewing 2001). While there is no agreed definition of organisational culture in the literature (Alvesson 2002), many researchers agree that it is shared by the organisational members, that it dictates their behaviour, that it takes time and shared history to form, and that it is difficult to put into words (O'Reilly, Chatman & Caldwell 1991; Quinn & Spreitzer 1991; Schein 1992; Alvesson 2002; Yauch & Steudel 2002). This study seeks to capture the influence of organisational culture on the adoption of Lean strategy by identifying shared organisational assumptions that affect scheduling decisions.

Capturing the impact of organisational culture on the adoption of Lean strategy has not been simple. Previous studies that attempted to quantify this impact achieved inconclusive or insignificant results (McDermott & Stock 1999; Shah, R. & Ward 2003; Nahm, Vonderembse & Koufteros 2004). Most measures of organisational culture are too abstract, and their direct impact on the adoption of Lean strategy cannot easily be identified. For example, a common measure of organisational culture, the Organisational Cultural Profile (OCP) (O'Reilly, Chatman & Caldwell 1991), measures the importance

of concepts like “flexibility”, “adaptability”, and “being careful”, which are difficult to link to practical incompatibilities between the existing organisational culture, and Lean practices. Another common measure of organisational culture is the Competing Values Framework (Cameron & Quinn 1999), which examines the dominant values in different aspects of a business, such as leadership, control mechanisms, and interpersonal relationships. This framework was used to identify cultures that are most supportive of Lean strategy in US manufacturing plants (McDermott & Stock 1999); however, the results were not definitive.

Another study attempting to identify cultural aspects that affect the successful adoption of Lean principles was more successful at attaining meaningful and practical results (Yauch & Steudel 2002). This study adopted Schein’s framework of levels of culture (Schein 1992), and was able to identify specific behaviours that impede the successful adoption of cellular manufacturing in discrete industry plants.

Accordion to Schein’s framework (Figure 2.3), cultures exist and operate on three levels. The lowest level is the level of underlying assumptions, which are shared amongst organisational members and guide their behaviour. The second level is the level of espoused values, which are unspoken beliefs of “what ought to be” the behaviour. The third and final level of organisational culture is the visible behaviour itself, as well as tangible artefacts (Schein 1992).

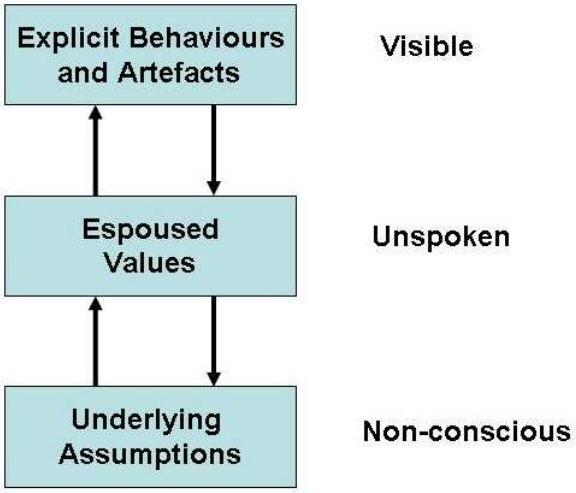

Figure 2.3: Levels of organisational culture (adapted from Schein 1992, p. 14)

This framework illustrates how complex organisational culture is, and why it can be hard to identify, measure, and link to the adoption of Lean strategy. Since the successful enactment of Lean strategy depends on behaviours that align with this strategy, it requires an alignment of the visible level of culture with Lean principles. However, on one hand, observing behaviours does not necessarily lead to a deep understanding of the underlying assumptions and espoused values that are driving them, and on the other hand, with the same underlying assumptions and even espoused values, culture could be manifested in different behaviours. Therefore, a direct link between the three levels of organisational culture and Lean principles is not easily identified. This difficulty is evident in another study that attempted to quantify the link between culture and the successful adoption of Lean principles. The study examined the espoused-values level of culture (Nahm, Vonderembse & Koufteros 2004); however, it showed mixed

results, with some Lean practices significantly linked to dimensions of organisational culture, others not.

The meaningful results attained from qualitatively examining the visible behaviours level of culture, along with the exploratory nature of studying the human factors in the steel industry that are involved in the implementation of Lean strategy, calls for a qualitative methodology. Such a methodology also enables the identification of factors that have not previously been identified, and provides a rich description of how these factors interact with one another. Scheduling decisions and behaviours related to them are therefore treated here as the visible level of the organisational culture. In addition, this study examines assumptions shared amongst organisational members that are relevant to the enactment of Lean strategy: the nature of value and business success, the way to achieve high production volume, and length of production lead time (Ohno 1988; Rother & Shook 2003; Womack & Jones 2003).

Organisational culture has the potential to impede the adoption of Lean strategy through status-quo bias, which impedes the adoption of any new practices. New behaviours required by Lean strategy (i.e., scheduling small batches and maintaining low inventory levels) can be rejected due to fear of negative consequences. For this fear to guide individuals, they do not need to experience such negative consequences themselves. Organisational culture is socially transmitted (Schein 1992), and thus influences organisational members without them directly experiencing consequences. This view is supported by Bate's study, showing how organisational culture can constrain problem-solving behaviour (1984), not through individual experiences, but rather through the socially acceptable norms and behaviours in the organisation. In other

words, a member of the organisation does not have to attempt a new behaviour in order to learn to avoid it.

This culturally-induced bias reinforces the status-quo bias mentioned in Section 2.3.2 (Kahneman & Tversky 1982; Inman & Zeelenberg 2002). Individuals perceive bad results from non-status-quo decisions as worse than bad results that conform to status-quo decisions. This fear of deviating from status-quo decisions can impede the adoption of Lean practices in scheduling, as they deviate from the status quo established in traditional production organisations.

2.5.4 Summary

Decision-making literature suggests that many factors and cognitive biases can impede the successful adoption of Lean practices by schedulers. Individual-related factors can impede the adoption of Lean scheduling practices through the schedulers' motives and experience. The characteristics of the scheduling task can also impede the adoption of Lean scheduling practices, such as the weight given to different sources of information, and the time horizon of the expected consequences of scheduling decisions. Finally, context-related factors can impede the adoption of Lean practices, through the need to justify decisions, and the influence of recent events. In addition, organisational culture can provide a contextual environment that does not support Lean practices, by upholding shared assumptions that promote status-quo scheduling decisions, rather than supporting new and different Lean scheduling practices. Table 2.2 summarises the various factors and biases.

Table 2.2: Factors relevant for production-scheduling decisions			
Factor		**Relevant biases**	**Sources**
Individual	**Attitudes** A learned evaluation of an object		Ajzen 1991; Bargh 1997; Slovic, Finucane et al. 2007
	Motives The motivational drivers of the decision-maker	• Commitment • Confirmatory • Persistence	Arkes & Ayton 1999; Bruner, Goodnow & Austin; 1986; Carter et al. 2007; Hogarth 1987; Kahneman & Tversky 1979; Karelaia 2006
	Experience Previous attempts and involvement in similar tasks	• Availability • Reference point • Selective perception	Carter et al. 2007; Haier, Siegel et al. 1992; Hogarth 1987; Klein 1993; Slovic et al. 2007; Tversky & Kahneman 2003; Tversky & Kahneman 1974;
	Capability Cognitive ability to address the problem		Simon 1978; Payne et al. 1993
Task	**Decision objectives** The final outcomes sought by the decision-maker		Louviere 1988; Keeney & Raiffa 1993; Clemen 1996
	Time Time available for decision-making		Bruner et al. 1986; Gilbert 1991; Hogarth 1987; Karelaia 2006 Sayegh, Anthony & Perrewé 2004; Sinclair & Ashkanasy 2005

	Information
	Information available to the decision-maker
		• Base rate
		• Presentation
		  ○ Mode
		  ○ Order
		  ○ Scale
		  ○ Mixture
		  ○ Framing
			Bar-Hillel 1990; Carter et al. 2007; Hogarth 1987; Kahneman & Tversky 1979; Keren 2007; Vessey 1994;

	Justifiability The need to explain and justify a decision to another		Lipshitz et al. 2001; Simonson 1992
Context	**Preceding events** **Short term** – events occurred prior to the decision, temporarily influencing the decision	• Reference point	Carter et al. 2007; Tversky & Kahneman 1974
	Preceding events **Long term**– events and consequences occurred prior to the decision, embedded in the organisational culture	• Status quo	Inman & Zeelenberg 2002; Kahneman & Tversky 1982

2.6 Human aspects in Lean manufacturing

Although schedulers have not been studied in the context of the adoption of a new strategy, operations literature has examined human aspects relevant to this adoption. Naturally, most of these studies were conducted in discrete industries, as Lean strategy is far more prevalent in those industries. In order to understand possible human and behavioural issues influencing the adoption of Lean in process industries, these studies are discussed below.

The operations-management literature refers to Lean manufacturing also as "just-in-time" (JIT), using these terms interchangeably, as they represent similar concepts: elimination of waste, maximisation of efficiency, and continuous improvement. Other studies have examined the conversion into cellular manufacturing (CM), where the organisation is divided not into functional departments, but rather into "cells" according to product families. These terms – Lean, Just-in-time, and cellular manufacturing – are the key concepts guiding the review of literature in this section. Since most studies were conducted in discrete industries, not all aspects apply to process industries. This point is addressed in more detail in Section 2.6.5.

The adoption of Lean manufacturing requires major organisational and operational changes (Power & Sohal 1997). From an operational perspective, it requires a shift from production of large quantities to small batches. Rather than having large safety inventories that act to buffer demand, organisations must retain low levels of "in-process" material (or WIP). Processes must be efficient and reliable, so that defects are avoided. Movements of people, parts and material must be minimised. All this, in turn,

can help eliminate the waiting time for material, people, and equipment (Ohno 1988; Rother & Shook 2003; Womack & Jones 2003).

From an organisational perspective, several changes are required for the successful adoption of Lean manufacturing. Structural changes are required, since work needs to be organised around product families instead of functional areas. The workforce has to shift from functional divisions into "cells" – each cell responsible for a product's entire manufacturing (Womack & Jones 2003). This requires a diversification of workers' skills. Moreover, the multi-skilled operators in a cell need to work as a team, and the teams, ideally, need to be self directed. Workers are expected to focus on a continuous improvement of the process, constantly striving for perfection.

These changes can be difficult to implement. Shifting into work teams means organisational restructuring, which often invokes fear and resistance. A requirement to diversify skills can also create resistance among workers. Although the proponents of Lean manufacturing claim these changes result in an enriched and engaging work environment, organisational changes can be challenging (Hackman & Oldham 1980; Kotter 1996; Morgan, D. E. & Zeffane 2003; Price et al. 2006). Areas of difficulty identified when Lean manufacturing is implemented are: (1) changing to work in teams, (2) developing a multi-skilled workforce, (3) implications of role changes in self-directed teams, and (4) continuous improvement (Karlsson & Åhlström 1995; McLachlin 1997; Humphreys, McAleer & McIvor 1999; Yauch & Steudel 2002; Fraser, Harris & Luong 2007). These areas of difficulty are discussed next.

2.6.1 Change to working in teams

Since working in teams is an important part of cellular manufacturing, the impact of the conversion of the work environment is important.

2.6.1.1 Relationships in work teams

McLachlin's 1997 quantitative longitudinal case study demonstrates the importance of relationships in work teams. Workers' production, quality, and labour productivity were compared before and after traditional divisions were divided into teams. The most cohesive team demonstrated the highest increase in all three measures of performance, whereas the team with the most conflicts did not display any performance improvement. The third team in the study fell between the two extremes in terms of both team relationship and performance. These findings are consistent with other findings showing that the promotion of teamwork is a necessary condition for successful implementation of just-in-time and quality (Karlsson & Åhlström 1995; Yauch & Steudel 2002).

One of the difficulties in team formations comes from team members' historical perceptions of one another. Teams in Lean manufacturing often include people who in the past worked in separate, and sometimes hostile, departments. Integrating these individuals into one operating team can result in conflict, illustrated by the following example (Humphreys, McAleer & McIvor 1999): an engineer and an operator, who were previously members of different organisational units, are made members of the same team. Their preconceived ideas about one another, however, sabotage potential collaboration: the engineer perceives the operator's questions as a threat to his authority, whereas the operator perceives the engineer's defensive response as being

condescending and insulting. This example shows the need to address social aspects when shifting into work teams, in order to reap the potential benefits of the integration of the various functions into a single team. This is consistent with the findings of Yauch and Steuel (2002), which showed that rigid group boundaries impede the conversion to cellular manufacturing.

2.6.1.2 The importance of teamwork

Workers have ranked "teamwork" as one of the most important human-related factors in cellular manufacturing companies (Fraser, Harris, & Luong, 2007). The more experienced workers (three years of service and above) claimed to have more human-related problems than technical problems. This finding shows that while over time workers become more comfortable with their area of expertise, the area of human relations remains problematic. This result suggests that an intervention may be required in order to improve human relationships.

In summary, the studies in this section (2.6.1) show the importance of relationships and harmonious teamwork, both to operational performance and from workers perspective. A criticism of Lean manufacturing in this respect has been that despite this importance, Lean manufacturing imposes a work environment that does not enable the social interactions necessary to establish such relationships (Delbridge 1998). The lack of time and conditions in which social interactions can develop thus negatively affects relationships between workers. Since positive interactions and cohesive relationships are the human foundation of successful cellular manufacturing, operational efficiencies may need to be occasionally sacrificed in order to sustain these crucial social aspects.

2.6.2 Multi-skilled work force

To increase production flexibility, just-in-time emphasises the need for multi-skilled employees. This enables dynamic allocation of human resources according to production needs (Billesbach 1994). The benefits of a multi-skilled workforce were found to go beyond this dynamic allocation, and to increases employee awareness of potential quality problems resulting from machine setup and operation (Olorunniwo & Udo 2002). Another contribution of multi-skilling may be job enrichment as well as facilitation of working in teams, thus answering the needs for social interactions (Monden 1994; Womack & Jones 2003). Sections 2.6.2.1-4 examine empirical results regarding issues that are relevant to multi-skilled workforces in Lean manufacturing.

2.6.2.1 Training

Not all companies provide formal training to diversify employee skills. Some companies rely on on-the-job training, previous experience, and learning by doing (Fraser, Harris & Luong 2007). However, formal training has been found to have a significant impact in cellular manufacturing success (Olorunniwo & Udo 2002). This study found that cellular manufacturing was more successful when employees were "cross-trained".

"Training" was also ranked as a high-importance subject for cellular-manufacturing employees (Fraser et al. 2007), as well as among managers of cellular manufacturing (McLachlin 1997). Technical and operational training provides workers with the tools to cope with their role-requirements. The importance of this justifies the allocation of resources (for financial and non-financial) to promote cross-training.

2.6.2.2 Organisational characteristics

Organisational characteristics such as plant size, age, and unionisation also have an effect on whether a work force is successful at being multi-skilled, or cross-functional. Unionised plants, as well as older plants, have been found to be negatively correlated with a cross-functional work force (Shah, R. & Ward 2003). Both unionisation and plants' age were found to impede organisational adoption of changes in general, and the adoption of Lean practices is thus more difficult in such plants.

Evidence regarding the impact of company size on the diversification of workers' skills is mixed. White, Pearson, and Wilson (1999) found that small companies are more likely to have multi-skilled employees than large companies, explaining that small companies are more likely to diversify the skills of their work force. Shah and Ward (2003) found no such difference in likelihood. However, compared to other Lean practices studied, Shah and Ward found the association of multi-skilled work force and with company size was weak. In general, large companies have more resources to enable the implementation of Lean practices; however, smaller companies need a multi-skilled work force, to achieve economies.

2.6.2.3 Incentives

The need to align incentives with Lean strategy is demonstrated in a case study of a discrete manufacturer that adopted Lean strategy (Karlsson & Åhlström 1995). In this study, when just-in-time was first implemented, employees were required to learn new skills in order to increase the production teams' flexibility. However, this requirement was not initially linked to an incentive scheme. A misalignment between Lean strategy and the incentive scheme was identified as an obstacle to the successful adoption of Lean

strategy. As a result, the incentive scheme was adjusted, linking the number of an employee's different skills to their base pay. This new link between employees' skills and pay rates motivated employees to learn new tasks, which led to greater team flexibility. This case study demonstrates how an alignment of employee incentives with the objectives of Lean strategy can support the formation of a multi-skilled work force.

Karlsson and Åhlström's 1995 study does not examine whether the motivation for cross-training, to obtain cross-functional skills, led to cross- functional work as well. There is evidence to suggest that switching roles is not always "enriching" for employees, but rather disruptive (Delbridge 1998). The pressure to keep up with time and quality demands encourages workers to prefer to specialise at performing a limited number of tasks in order to successfully complete them. Rather than job enrichment, multi-skilling is reported in Delbridge's 1998 study to inflict additional pressure and intensify workload. Even in Karlsson and Åhlström's 1995 study, no intrinsic motivation to acquire additional skills was demonstrated: financial incentives needed to be present in order to facilitate this aspect of Lean strategy.

2.6.2.4 Cross-functional managers

Another aspect of cross-functional work is not the cross-functional worker, but rather the cross-functional *manager*. Fawcett, Magnan, and McCarter (2005), after interviewing 51 senior-level supply-chain managers, emphasise the need for managers who have an understanding of the roles and challenges of the various value-adding activities across the organisation. This understanding can reduce the impact of the selective perception bias discussed in Section 2.3.2 above, which can result from managers' previous work experience. By exposing managers to various problem

domains, their selective perception can be broadened to include the additional domains in their interoperation of problems.

2.6.3 Role change in self-directed teams

Cellular manufacturing entails a change of role for workers and managers alike. Workers are required to assume more responsibilities, whereas managers are required to shift from "policing" to "coaching". These changes require employee empowerment, which does not necessarily lead to favourable results. A study of employees' reaction to change into self-managed work teams showed that employees' concerns about undesirable job assignments and added responsibilities led to higher resistance to the change, and to a reduction in job satisfaction and organisational commitment (Kirkman & Shapiro 2001). In addition, employers operating in traditional functional roles demonstrated a higher job satisfaction and stronger organisational commitment compared with cellular-manufacturing employees (Shafer et al. 1995). These results suggest that self-directed work teams are not necessarily favoured by employees.

The requirement in cellular-manufacturing, and in Lean strategy in general, to empower employees and to get them to assume greater responsibilities can be problematic from a motivational perspective. McGregor's (1960) Theory X and Theory Y of human motivation provides an explanation of this discrepancy. According to this theory, managerial decisions are made based on assumptions of human nature and human behaviour. Theory X rests on the assumption that employees dislike work, prefer to avoid responsibility, and must be coerced and directed in order to produce results that are favourable to the organisation. This is the traditional way of viewing employees. In contrast, Theory Y assumes employee and organisational goals are aligned, and thus

employees are assumed to be intrinsically motivated to work, and their commitment to learn can be stimulated by rewarding them for wanted results.

Lean strategy in general, and cellular manufacturing in particular, rely on Theory Y employees to expend effort in order to advance organisational goals. However, when shifting from traditional functional roles, which relied on Theory X methods of motivation, Theory Y motivational methods and expectations may not be appropriate. Supporting this assertion is the finding that unionised and old plants were less likely to implement self-directed teams (Shah, R. & Ward 2003). Although unionisation can empower employees and therefore can be expected to assist in the adoption of self-managed work teams (Karger 1990), unionisation indicates a coercive relationship between workers and management, consistent with Theory X. In addition, old plants pose difficulties when adopting new work practices (Nelson & Winter 1982), and thus workers and managers can find it more difficult to adopt a new motivational perspective.

Another important aspect of Lean strategy that relies on Theory Y motivational practices is the continuous search for improvement. This aspect is examined next.

2.6.4 Striving for perfection – continuous improvement

Many continuous-improvement schemes, such as ISO, Six Sigma, Business Process Renovation (BPR), and Total quality Management (TQM), have been adopted by organisations along with Lean manufacturing. Such continuous-improvement programs, as suggested by Detret, Schroeder, and Mauriel (2000), require various supporting cultural values: relying on long-term orientation, belief in intrinsic employee motivation, constant aspiration for improvement (as opposed to reaching stability), internal process improvement aiming to achieve results, internal and external

collaboration and cooperation, and strong customer orientation. Studies reveal the influences of different organisational factors and practices on the perfection aspect of Lean manufacturing.

2.6.4.1 Impeding factors

Many organisational factors can impede continuous-improvement efforts. A study by Yauch and Steudel (2002) revealed seven organisational factors that impede conversion to cellular manufacturing, and in particular, inhibit continuous improvement of the operation: under-organising, avoidance, lack of mutual respect and trust, lack of crisis urgency, complacency, rigid group boundaries, and overemphasis on core activities. Under-organisation not only hindered the conversion to cellular-manufacturing, but also caused waste of workers' time and effort. Avoidance undermined workers motivation to make improvement initiatives, as the organisational culture tends to punish people for mistakes. Lack of mutual respect and trust between workers and management also stops workers from taking improvement initiatives. Crisis urgency (or lack of) and complacency are two inter-related factors, both undermining workers' motivation to improve. In the lack of crisis urgency, complacency about and resignation to existing problems are accepted.

Rigid group boundaries make the flow of information and improvement ideas difficult. Finally, overemphasis on core activities, rather than on improving processes or systems, was also found to negatively influence continuous improvement.

2.6.4.2 Supporting factors

The only factor Yauch and Steudel (2002) identified as having a positive effect on conversion to Lean manufacturing was external customer focus. The study found

customer orientation supported initiatives for change, if the change would directly affect customer satisfaction. This is consistent with a survey of 224 companies (Nahm, Vonderembse & Koufteros 2004) showing that companies with strong customer-orientation values correlate with the adoption of Lean manufacturing, and that these values are positively related to performance.

Financial incentives were also found to affect continuous improvement, as shown by Karlsson and Ahlstrom (1995). In their study (mentioned in Section 2.6.2.3), the remuneration system was changed along with the adoption of Lean production. Apart from a fixed component of employee salary, a bonus component was designed. It depended on the team achieving: productivity, quality, and timely delivery. In this study, productivity was measured as production time compared to standard production time. Quality was measured as number of defects, and only zero defects resulted in a bonus. Timely delivery was measured in terms of orders delivered on time. The bonus that was conditioned on zero defects had a visible impact on workers focus. Employees took measures to correct defective parts and avoid their delivery. They were observed to become more efficient, not tolerating missing parts, in order to achieve the timeliness bonus. This demonstrates a possible way to get workers motivated and involved in improving operations. However, this study only observed a short period of time after the adoption of Lean startegy– a limitation acknowledged by the authors. It may be difficult to maintain constant, unstructured efforts for improvement over longer periods of time. Further research to discover other supporting organisational factors is required.

2.6.4.3 Maintenance

Although preventive maintenance has been identified as critical for the successful implementation and sustainability of just-in-time (Spencer & Guide, 1995), evidence shows that maintenance practices are generally not adjusted (Swanson, 1999). This is explained by the need for different maintenance practices being less apparent to managers, since just-in-time does not involve major changes in technology. This lack of attention to maintenance is reflected in the equally poor focus in the literature in this field (Pintelon, Pinjala, & Vereecke, 2006).

2.6.5 Relevance to process industries

Some aspects of Lean strategy discussed in the literature are not applicable to the steel industry: cellular-manufacturing cannot be adopted in the steel industry due to large and capital-intensive equipment, which prevent the possibility of rearranging manufacturing according to product families (Abdullah & Rajgopal 2003; Dhandapani, Potter & Naim 2004; Belvedere & Grando 2005; Harrison 2005). Cross-functional workers are not necessary for flexibility, as the main source of value-add in process industries is not through human activities but rather through a chemical process (Dennis & Meredith 2000; Crama, Pochet & Wera 2001).

However, findings from this industry section remain critical to the successful adoption of Lean strategy in the steel industry. Collaboration between different functions (such as engineering and production, or engineering and sales) remains critical to successful operations. Even when not performed in a cellular setting, collaboration between different functions in the business unit is still necessary for effective production. Since the production process involves many stages which can affect one another, cross-

functional awareness and a collaborative focus provide schedulers with the context necessary to facilitate scheduling decisions that take into account an overall perspective, and to justify decisions that have a negative impact on some localised functions.

Other contextual factors highlighted by these studies is the importance of maintenance practices, which can facilitate a predictable and stable environment for the scheduler to operate in, and cultural elements that support collaboration and continuous improvement in the organisation. These factors (under-organising, avoidance, lack of mutual respect and trust, lack of crisis urgency, complacency, rigid group boundaries, and overemphasis on core activities) can impede collaboration and continuous improvement in steel-manufacturing organisations that seek to adopt Lean strategy. Another relevant aspect of organisational culture is the discussion of Theory X Theory Y employees. Lean strategy requires Theory Y employees; however, steel industry plants are typically old and unionised, which corresponds with Theory X managerial approach.

In addition, these studies show that incentives structures need to be revised and aligned with Lean practices. The traditional incentives in process industries are designed to encourage production of large quantities and high product quality (Narayanan & Raman 2004), which encourages local optimisations rather than cross-organisational performance. Incentives therefore need to be modified to reflect the goals of Lean strategy, in order to motivate behaviours that align with it. These human aspects are expected to play a role in the process of adopting Lean strategy in the steel industry.

Finally, schedulers, who are central to the operational decisions that are vastly affected by the adoption of Lean strategy, are not mentioned in studies examining human issues accompanying this adoption. This raises the question, how would schedulers in

the steel industry, who rely on practices thoroughly different to those required by Lean strategy, deal with this adoption? This warrants a comparison of the role of the schedulers in the steel industry with previous descriptions of schedulers, examined in Section 2.1. This comparison is addressed by research sub-question 2 (Table 1.1).

2.7 Making scheduling decisions that support Lean strategy – a summary of relevant literature

In order to address the general research question guiding this research, and to identify factors that impede a successful and sustainable adoption of Lean strategy in the steel industry, this chapter has examined three main bodies of literature: (1) literature on schedulers, (2) literature on decision making, and (3) literature on adoptions of Lean strategy in discrete manufacturing industries. This section summarises the main points that have been identified.

Literature reviewed in this chapter shows that scheduling is a complex task performed by a scheduling team. Although these teams have a significant accumulated influence on the execution of business strategies, their role in the adoption (or rejection) of Lean strategy has never been studied before, and very few studies of their influence in the process industry exist. This gap guides RSQ1 (Table 1.1).

When examining the decisions that schedulers make, decision-making literature suggests that many factors and cognitive biases can impede the successful adoption of Lean practices by schedulers. Individual-related factors can impede the adoption of Lean scheduling practices through the schedulers' motives and experience. Literature on the implementation of Lean strategy focuses mainly on financial incentives, however their influence on schedulers has never been examined. Other individual factors that

may bias schedulers' decisions, such as experience, attitudes, and capabilities, have also not been previously examined.

Decision making literature suggests that other factors, grouped into Task and Context factors, may have an influence on schedulers' decisions. The characteristics of the scheduling task can also impede the adoption of Lean scheduling practices, due to the weight given to different sources of information, and the time horizon of the expected consequences of scheduling decisions. Indeed, previous studies of schedulers show that scheduling teams often do not have the formal power to carry out their responsibilities, and they thus use relationships to influence other parties involved in the production. These relationships with various business functions (i.e., sales, engineering, and production) and with various business units along the supply chain impact on how schedulers interpret the scheduling task, and how they construct a decision. In addition, context-related factors can also impede the adoption of Lean practices, through the need to justify decisions, and the influence of recent events. Literature on the adoption of Lean strategy emphasises the need to create a predictable and stable production environment, which provides a specific context for scheduling decisions. However, the influence of such contextual factors on the decisions of schedulers has also never been studied. This gap in literature requires an answer to RSQ2 (Table 1.1).

Contextual factors are perhaps the most complex group of decisions factors to study. These factors include the need to provide justification for the decisions, and the influence of organisational culture. Both these issues suggest potential impedances to the adoption of Lean practices. The need to provide justification for decisions means that decision makers need to take into account the views of other stakeholders, which

may have their own agenda with regards to Lean practices. Organisational culture has been identified as a potential impedance to the adoption of Lean strategy through status-quo bias, which impedes the adoption of any new practices (Kahneman & Tversky 1982; Inman & Zeelenberg 2002). Literature on organisational culture also identifies a level of shared assumptions (Schein 1992), whereas literature on the adoption of Lean strategy identifies how such assumptions can affect the successful adoption of the strategy (Nahm, Vonderembse & Koufteros 2004). Although the influence of organisational culture on the successful adoption of Lean strategy has been examined, no examination of this influence on schedulers' decisions during such adoption has been conducted, neither in discrete industries, nor in the steel industry. This gap raises the final research sub questions, RSQ3 (Table 1.1).

The research questions in this study require an in-depth investigation of many inter-related and complex issues. This investigation is conducted using a methodology of a qualitative case study. The methodology and the methods used to thoroughly address these questions are elaborated in the next chapter.

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Chapter 3 Research methodology and design

This chapter describes the methodology employed in this research. It provides a detailed description, analysis and interpretation of the human aspects relevant to scheduling decisions that support or impede the adoption of Lean strategy. This research is exploratory in nature, and identifies the reasons that undermined the sustainability of Lean strategy in a steel-manufacturing organisation. This research also employs a descriptive approach to identify and depict the factors in the steel industry that currently influence the performance of Lean scheduling practices. Data were collected from interviews, focus groups, and organisational documents. A thematic analysis was used to extract meaning from the data, and to identify factors relevant to the research question. This chapter describes and justifies this research design.

3.1 Research approach

Thus far, this thesis has emphasised the importance of schedulers' decisions to the operations of a production and manufacturing organisation. However, scheduling in the context of adopting a new strategy has not been previously studied. Therefore, this study aims to uncover the individual, task-related, and contextual factors that support or impede schedulers' adoption of Lean strategy in the steel industry.

For this purpose, case study research was chosen. Case study research enables the researcher to gain a deep understanding of scheduling decisions and factors that influence these decisions in real work setting. It is particularly valuable when the intention is to examine phenomena in their natural setting (Meredith 1998), and it is a powerful approach that can provide a rich set of data on real-world practice (Voss, C., Tsikriktsis & Frohlich 2002; Berglund & Guinery 2008). Case studies are used to

explain phenomena when the researcher has limited, if any, control over events, behaviours, and conditions, and when the focus is on contemporary and contextual events (Yin 2003). In addition, the formulation of the research questions also guides the selection of a research approach. According to Yin (2003), case studies are appropriate when the research seeks to address "how" and "why" questions. The questions of this research are mainly interested in how and why Lean strategy is accepted or rejected in the steel industry, therefore suggesting case study research is appropriate.

The type of case study research employed in this study is a combination of a retrospective and longitudinal case study of a single company. This research perspective enables a thorough, in-depth analysis of the human aspects involved in the adoption of Lean strategy (Klein, H. & Myers 1999; Voss, C., Tsikriktsis & Frohlich 2002), by examining retrospective views of an unsuccessful attempt to implement Lean strategy. This examination identified factors that influenced scheduling decisions, as they were revealed during the implementation of Lean strategy.

A major benefit of a retrospective approach is the reliability of the case's selection. Since the success, and particularly the sustainability, of strategy implementation can only be evaluated in retrospect, a retrospective case selection is more reliable in terms of identifying this success (or sustainability) (Voss, C., Tsikriktsis & Frohlich 2002).

A retrospective case study, however, is subject to the following potential problems (Voss, C., Tsikriktsis & Frohlich 2002):

1. Interview inaccuracies – participants may not recall important events, or their recollection may be biased. A particular problem is post-rationalisation: events are interpreted differently in hindsight, compared to how they were interpreted at the time.

2. Archival inaccuracies – archival data, such as meeting minutes and other documentation, may not always reflect the whole truth, as difficult or controversial items may not appear.

To address these problems, Voss et al. (2002) suggest employing a longitudinal approach. Therefore, the study also examined contemporary scheduling practices in the organisation's business units, in order to gain contemporary perspective on the forces that support or impede Lean strategy. Another reason to examine factors influencing current scheduling factors is availability. Schedulers involved in the adoption of Lean strategy were not available. However, current schedulers were able to provide their perspective on the factors that influence their decisions to adopt (or reject) Lean scheduling practices.

This study gained a longitudinal perspective by a "combination of retrospective and real time analysis" (Pettigrew 1990, p. 271). By comparing retrospective views on past scheduling practices with current scheduling practices in the same organisation, this study gains a longitudinal perspective of these practices. Since the practices were studied in different units, the study sought to identify similarities between past and present. In addition, current schedulers often provided an insight on past practices in their units, which were compared with past practices identified in the retrospective accounts. Most interviewees had tenure of over 10 years in the company, and typically worked in more than one unit. Therefore, their experience and knowledge extended the

practices common in their unit only. This provided a longitudinal view of scheduling practices that were common throughout the entire organisation, and not only in specific unit. This is a great benefit of the case study approach – it provides a richer historical, contextual, and processual perspective, which are critical to the understanding of organisational change (Pettigrew 1990).

To gain a comprehensive understanding of factors influencing schedulers' decisions, contemporary scheduling practices were studied in two different units. The selection of these units, or sampling, was based on the similarity of their operations to the operations in the unit of Lean implementation, and is further described in Section 3.2.

This case provides a unique opportunity to learn about factors that impede the sustainability of Lean strategy over time in a process industry, as it describes an implementation of Lean strategy that was initially successful, but over time was rejected due to constant resistance. This is in contrast to most cases in the literature, which describe a snapshot in time of a successful implementation (e.g., Abdulmalek & Rajgopal 2007). Other descriptions of the implementation of Lean strategy report failures (e.g., Yauch & Steudel 2002). However, a rich description of the factors that can lead to a rejection of Lean strategy after initial success extends the understanding of factors that have a prolonged and persistent effect on its enactment.

Examining a past attempt to implement Lean strategy provides an understanding of human factors that influence its adoption. Examining current scheduling practices enables triangulation of the findings identified in the implementation case, and reveals contextual factors involved in scheduling decisions that influence the execution of Lean

strategy. Examining contemporary scheduling practices also shows longitudinal changes in the organisation that are relevant to the adoption of Lean strategy in the steel industry.

3.2 Case selection

The organisational units and data sources selected for this study enables exploration and comparison of human aspects that are specific to the adoption of Lean strategy in the steel industry, as well as an in-depth understanding of factors that influence schedulers' decisions. Two types of organisational units were selected for this study. One unit was involved in a past attempt to implement Lean strategy in a steel-manufacturing organisation (i.e., a retrospective case study: Lean implementation at the mill). This unit was selected due to the extreme degrees of effort, expertise, and resources devoted to this implementation (see Appendix B) on one hand, and the gravity of the consequences of rejecting the strategy on the other hand. Examining this implementation in depth provides an important opportunity to identify challenges unique to the adoption of Lean strategy in the steel industry.

The other type provides a longitudinal perspective on the adoption of Lean strategy in the steel industry, as well as a more detailed understanding of factors that influence scheduling decisions. This type includes two business units along the supply chain of the same steel manufacturer, whose traditional manufacturing has been modified to include some Lean aspects. These two units, here called Unit A and Unit B, were selected based on the Lean practices that apply to them. Both units are able to adopt Lean practices that are similar to the practices implemented in the unit of retrospect. Like that unit, the two other units regularly process discrete products. These products are different to discrete-industry products in terms of size, and therefore cellular

manufacturing is not possible (Abdullah & Rajgopal 2003; Abdulmalek & Rajgopal 2007). In addition, these products undergo a process of changing the material's physical attributes, thus imposing limitations on changeovers and processing capacity. However, paced production and lower WIP levels are possible and can be beneficial to these production units. Examining scheduling practices in these units enables an in-depth understanding of scheduling practices in the steel industry, and the factors that influence schedulers when they make decisions influencing the adoption of Lean strategy.

Access to these units was suggested by a task force from the steel manufacturer. This task force was involved in this study, and was founded in order to re-examine the applicability of Lean strategy to the organisation's supply chain. The task force was thus interested in identifying human issues that had caused the adoption of Lean strategy in the organisation to fail.

3.2.1 Selection of participants

No previous studies describing human issues that support or impede the sustainable adoption of Lean strategy in the steel industry had been done at the time of this research. This called for exploratory study, to identify these issues and how they operate. Thus, participants were interviewed in the order prescribed by Grounded Theory, where similar viewpoints are sought first, in order to construct a basic understanding of the examined phenomena (Glaser 1978). Then, after this basic understanding is reached, the researchers seeks interviewees with perspectives and viewpoints as different as possible, in order to identify differences to the formed perspective and distil the main themes.

For the retrospect case, the first two interviewees were senior members of the Lean implementation team. Subsequent interviewees provided the perspectives of other members involved in this implementation, including engineers and hands-on change managers.

In addition to participants who were directly involved in this implementation, participants offering a broader understanding of contextual factors were interviewed. These participants (John and Collin, Table 3.1) informed this study of conditions that are typical to the steel industry, to this organisation, and to the implementation of Lean strategy.

For contemporary scheduling, members from the different units' scheduling teams were interviewed. Interviews were conducted with individuals who were identified as key stakeholders in the scheduling process, and voluntarily agreed to participate in this research. First, members of Unit A's scheduling team were interviewed, and after the data had been analysed, members from Unit B's scheduling team were interviewed. Fewer members from Unit B were interviewed as few relevant were revealed in the Unit B interviews. At that stage, interviews were stopped.

Table 3.1 summarise participants, their unit of origin, and their role. Participants appear in order of interviews.

Table 3.1: Participants		
Case study	**Participant**	**Role**
Implementation	Ross	Program sponsor
	Cameron	Program director
	Collin*	Lean implementer
	Fiona	Implementation team manager
	John*	Senior HR manager
	Ian	Team leader, implementation team member
	Ron	Team leader, implementation team member
	Vincent	Implementation champion, manager
Current scheduling – Unit A	Lee	Planner and scheduler
	Fred	Master scheduler
	Sam	Unit scheduler
	Paul	Unit scheduler
	Ronald	Shift controller
Current scheduling – Unit B	Owen	Planner and scheduler
	Alice	Novice scheduler
	Vera	Unit scheduler

* Participants external to the implementing unit, offering a broad perspective

3.3 Data Collection

Data were collected through interviews, focus groups, and archival documents. Combining data sources increases construct validity in case study research (Denzin & Lincoln 1994; Yin 2003); this aspect is addressed in more detail in Section 3.5. Each data source is addressed separately below.

3.3.1 Interviews

To provide standardisation, and thus contribute to the reliability of the findings of this study, an interview protocol was developed for each interview set. The interview protocols provided an explicit agenda for the researcher's line of inquiry and aimed to help the researcher to minimise errors and biases in conducting the interviews. These protocols were set up to ensure that the interviews were conducted consistently across participants, and hence substantiated the reliability of the study (Gibbert, Ruigrok & Wicki 2008). Since the two interview sets differed in participants (implementation-team members versus current schedulers), and in aims (exploring reasons for rejecting Lean strategy versus understanding current influences on Lean scheduling decisions), different interview questions and protocols were developed. These protocols are presented in Appendix C. Although these protocols served as a guide for completeness of issues addressed, in most interviews, participants led the conversation, with minimal intervention. This interviewing strategy was selected in order to avoid biased and partial responses (Gibbert, Ruigrok & Wicki 2008).

Prior to an interview, respondents were given an overview that explained the goals of the project and the interviews. The company liaison gave the researcher a description of the individual's role, common motivators and decision drivers, as well as

typical organisational conditions in the individual's unit. This information enabled a better focus during the interview. An interview was scheduled to last for up to an hour; however, some interviews lasted up to ninety minutes. No other parties were present during interviews (accept for one interview in Unit B, where the planner was joined by a novice scheduler). The interviews were recorded and transcribed by an independent transcription service. Transcriptions were edited by the researcher, as some terms were incorrectly transcribed.

Due to a technical problem, half of the interview with one participant (Vera, Unit B), was not recorded and thus not transcribed. At the end of the interview, the researcher wrote the main themes discussed in the interview based on her memory. In addition, the researcher regularly documented her reflections after interviews, in order to capture general impressions and potential biases. These reflections were consulted during data analysis, to remind the researcher of contextual effects.

3.3.2 Focus groups

An important source of data triangulation was regular focus groups conducted as part of this research (Morgan, D.L. & Spanish 1984). This research was part of a larger project. Part of the project involved regular focus-group meetings with members of the organisation studied. These meetings were not recorded or transcribed. However, the researcher took notes and minutes, which were then sent to the other participants for approval.

Focus groups met regularly on a weekly basis for a period of six months. During these meeting, the following issues were discussed:

- Schedulers' incentive schemes

- Schedulers' performance measures
- Business-unit performance measures
- Collaboration across business units
- Collaboration within business units
- Schedulers' control over production decisions in different units
- Motivators for high inventory levels
- Mechanisms of resistance to Lean practices
- Operational factors involved in scheduling decisions
- Shared assumptions regarding scheduling practices
- Common scheduling priorities

Each focus-group meeting was summarised by the researcher, and the summary was sent to the rest of the participants for comments. Periodic summaries were presented to a larger forum, which included experienced and high-ranking managers in the organisation, for validation.

These summaries were used for triangulation, to evaluate the completeness of the data collected (Breitmayer, Ayres & Knafl 1993). The summaries were compared to views presented by interviewees. Congruence between focus-group meeting summaries strengthened interviewee views, whereas incongruence indicated that further investigation is needed, until an understanding of the discrepancy has been reached.

3.3.3 Documents

Several organisational documents were examined in order to triangulate the findings identified during interviews and focus groups. Most documents supported and illustrated the researcher's understandings. On occasion, documents presented themes

that were new to the researcher. These documents were then discussed with the company liaison, and the new theme was either integrated into the findings, or discarded, if it was not pertinent to the understanding of the forces that determine scheduling practices or to the understanding of the rejection of Lean strategy. Table 3.2 summarises the documents, their content, and their relevance.

Table 3.2: Documents examined in this study and their relevance

Documents	Relevance
Lean strategy training and education documents	Establishing implementation rigour Establishing implementation educational approach
Reports on training progress	Establishing implementation rigour Establishing education follow-up
Current business-analysis documents	Understanding current scheduling practices Confirming identified contextual factors influencing scheduling
Planning and scheduling review	Understanding and confirming scheduling practices, information sources, and processes

3.4 Analysis

The purpose of analysis is to draw meaning from the data (Miles & Huberman 1994). This process involves selecting data items, interpretation, and synthesising findings. Data were selected and interpreted through thematic analysis, which seeks meaningful extracts of data items. These extracts are "illustrative of the analytic points the researcher makes about the data, and should be used to illustrate/support an analysis that goes beyond their specific content, to make sense of the data, and tell the reader what it does or might mean" (Braun & Clarke 2006, p. 94). The way these extracts were identified is described in the following sections, as their identification relies on the selection of data items, their coding, and deriving meaning from them. These extracts, along with the points that they indicate, are presented in Chapter 5 as the findings of this thesis. The next section presents the process of analysis undertaken in this study.

3.4.1 Selecting data items

Selecting data to be analysed is endemic to the data-collection process (Miles & Huberman 1994). For example, during interviews, data sources such as participants and questions are selected deliberately. In contrast, such selection is not always deliberate during observations as the researcher determines what to note and register. This renders at least some of the data selection intuitive to the researcher.

The selection of interviewees and interview questions has already been discussed in Section 3.2. In addition, documents were selected for analysis in this study based on their utility in supporting understandings formed through interviews and focus groups. These documents served as tangible evidence confirming statements and constructs emerging from previous data. Documents were selected based on their pertinence to the

scheduling process, their pertinence to the understanding of shared assumptions relevant to the adoption of Lean strategy, and their illustration of the forces that operated during the implementation of Lean strategy in the organisation.

3.4.2 Coding

Three levels of coding were used: *descriptive*, *interpretive*, and *pattern* (Miles & Huberman 1994). All coding was done using a qualitative analysis software (NVivo 7 'Nvivo' 2007), which supports a smooth transition between the various stages.

Descriptive coding attributes a class of phenomena to a segment of text, with little or no interpretation. For example, an answer to the question: "How was Lean strategy introduced in the mill?" was coded under the category "Introducing Lean". Due to its content, this was also coded under sub-category "Teaching theory".

Interpretive coding was far more prolific. This coding level involved the researcher's judgement, and meaning was extracted based on how the data item reflected the theme addressed. For example, a document developed after Lean strategy had been implemented, which explains how small batches do not reduce utilisation, but do reduce production lead-time, demonstrates that resistance to Lean strategy in this unit was due to the fear of falls in utilisation and production levels. The statements in this document, which reinforces the effects of Lean strategy on lead-times, and its lack of effect on utilisation and production levels, were coded as "Resistance to Lean", under the sub-category "High utilisation and production".

Finally, *pattern coding* requires matching the categories previously identified in both research phases to produce a holistic picture of the underlying causes to the rejection of Lean strategy. For example, several factors that impede Lean scheduling

practices stemmed from emotional motivation. This led to the understanding that emotional aspects are involved in scheduling decision-making, when schedulers are required to adopt Lean practices.

These three stages were also applied when coding current scheduling practices. *Descriptive coding* was used to categorise the task, individual, and contextual factors influencing scheduling decisions, based on the framework summarised in Figure 2.2 (Appendix A contains the identified factors). In addition, schedulers' roles were identified based on predefined categories. These categories include information node, negotiator and influencer, and problem anticipator and solver, as described in Section 2.1.2. However, one role of schedulers, which had not been defined explicitly before, became evident – the scheduler as a strategy executor. These categories are presented in Section 5.1.

Next, *interpretive coding* was used to identify the influences of various factors on the adoption of Lean strategy. Influences were divided into supporting and impeding influences. These codes were condensed into categories presented in Section 5.2.

The final stage of analysis sought to understand the assumptions shared by members of this organisation that led to scheduling decisions that did not align with Lean strategy. At this stage, *pattern coding* revealed assumptions that need to be shared to enable the adoption of Lean strategy in a steel-manufacturing organisation. These assumptions are presented in Section 5.3 and discussed in Section 6.3.

3.4.3 Creating codes

This research employs thematic analysis to identify the human aspects relevant to the adoption of Lean practices by schedulers in the steel industry. Thematic analysis

seeks to identify, analyse, and report patterns (themes) within the data (Braun & Clarke 2006). It demands that the researcher play an active role in the identification, selection, and reporting of these themes. This analysis is conducted in three distinct stages (Boyatzis 1998).

Stage I: Deciding on sampling and design issues. This stage has been addressed in Sections 3.2 and 3.4. Participants were chosen based on the key role they played in implementing Lean strategy, their influence on current scheduling practices, and their ability to provide contextual information on industry and organisational characteristics. Documents were selected for analysis based on their ability to testify to the validity of the researcher's understanding.

Stage II: Developing themes and codes. This stage requires deciding what counts as a theme, and what approach the coding process is based on: deductive or inductive. A theme is defined as "a specific pattern found in the data in which one is interested" (Joffe & Yardley 2003, p. 57), or similarly, "[a] theme captures something important about the data in relation to the research question, and represents some level of *patterned* response or meaning within the data set" (Braun & Clarke 2006, p. 82, italics original). These definitions consistently describe a theme as a concept that researcher sees as relevant, and which repeats itself systematically in the data set. This renders the researcher's judgement central to the coding process.

In addition, themes can be identified based on a predefined framework using a top-down approach (Boyatzis 1998), or they can emerge bottom-up from the data, as common in Grounded Theory (Glaser & Strauss 1967). In this study, although both the data collection and analysis stages had initial lists of codes (which was based on the

factors identified in Chapter 2, summarised in Table 2.2), additional categories (or themes) became evident during the analysis phase. These categories were instrumental in addressing the research questions, as they helped in understanding the underlying human factors that led to the rejection of Lean strategy in the steel-manufacturing organisation studied, as well as the shared assumptions that can lead schedulers to perform or avoid Lean practices at present. Thus, an inductive, data-driven approach was beneficial in this study to arrive at novel insights.

Stage III: Validating and using the codes. At this stage, codes found in the data are compared to codes derived from literature. Their presence or absence is examined relative to exiting theory (Boyatzis 1998). This presence or absence indicates the whether the findings support, refute, or extend theory. However, when the codes are data-driven, they need to be validated (Miles & Huberman 1994). The next section describes the steps taken to ensure construct validity in this study.

3.5 Validity and reliability of constructs

This study sought to address three types of validity (*internal*, *construct*, and *external*) based on a framework for rigorous case studies (Gibbert, Ruigrok & Wicki 2008).

Internal validity, also called "logical validity" is concerned with causal relationships between variables and results (Yin 2003). It is concerned with the researcher's logical reasoning and compelling argument, to support their conclusions. This type of validity is established by the researcher's awareness of multiple theoretical frameworks at the time of the analysis (Gibbert, Ruigrok & Wicki 2008). Data were

analysed based on a decision-making framework and a change-management framework (Appendices I and II).

The second type of validity addressed in this study is *construct validity*. This refers to the quality of conceptualisation and application of the relevant concepts. To establish construct validity, two measures were taken: data triangulation (by comparing participants' account to internal documents and reports), and constant review of the findings by different experts (Gibbert, Ruigrok & Wicki 2008). After each focus group (Section 3.3.2), a summary of the researcher's understanding was sent to the participants. Focus-group members then reviewed the document to ensure concepts were correctly understood and presented. Discrepancies were pointed out, and the findings were updated accordingly. In addition, these findings were aggregated and presented to a wider audience on a yearly basis. Comments received from other organisational members were taken into account and findings were revised accordingly.

External validity, or 'generalisability', refers to the ability to extrapolate from the conclusions of the case study to theory that can be applied in other settings (Gibbert, Ruigrok & Wicki 2008). To establish external validity, this study provides ample detail on the context of this case study (see Chapter 4), as well as a justification for the selection of this case study (Section 3.2). Table 3.3 summarises the measures taken to ensure these types of validity.

Table 3.3: Measures taken to ensure validity in this study		
Validity type	**Measures taken**	**Phase**
Internal	▪ Multiple theoretical frameworks	Analysis
Construct	▪ Data triangulation	Data Collection
	▪ Review of findings by participants and third parties	Validation
External	▪ Details of case context	Reporting

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Chapter 4 Cases descriptions

The organisation studied is an Australian steel manufacturer that traditionally operated based on push production strategy – processing large batches and queuing orders. A background description of this organisation is provided in Section 4.1.

The organisation has attempted to implement Lean strategy in several units over the past few years. The first unit in which Lean strategy was implemented was the mill. A description of this implementation is provided in Section 4.2.

Finally, two business units were studied in order to understand their scheduling practices. Figure 4.1 illustrates how the two units are positioned in the organisation's supply chain. It can be seen that the units are not at the beginning of the supply chain, and that they have a similar positioning in regards to their customers. The units are described in more detail in Section 4.3.

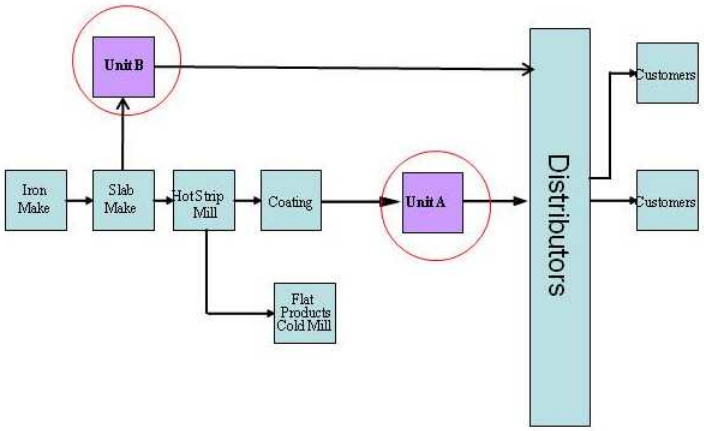

Figure 4.1: The organisation's internal supply chain and studied units

4.1 Background – organisation studied

The organisation studied is a multinational steel-manufacturing business with considerable experience of internal supply chains. The culture of the organisation can be

implied from some of the following characteristics. It is a major employer in its region, and many of the employees joined the organisation with little or no professional training. The organisation is hierarchical and centralised, and has well-established control mechanisms such as performance measures, policies, levels of authority, and financial incentives. The workforce is mostly male, and tenure is commonly over 15 years. However, most senior management positions turn over about every five years. Since the 1980s, the organisation has gone through three major restructures, during which the workforce has dropped from over 20,000 employees to under 4,000.

The organisation constantly seeks to improve operational performance by reducing production lead times, as well as increasing timely delivery, reducing inventory levels, and achieving better product quality.

4.2 The implementation of Lean strategy – the mill

Lean strategy was implemented in the mill as a joint effort of a corporate-sponsored Lean implementation team, and the mill's top management. The implementation team was educated in Lean strategy tools and techniques over a period of 12 months. This education involved interactions with world experts and observations of Lean organisations internationally. The team developed a detailed implementation plan for employees' education, and followed up to ensure workshops were attended as planned. The team also developed policies and procedures that enforced Lean work practices, such as kanbans, maintenance schedules, and layout modifications, and ensure the practices were followed. A detailed description of the efforts invested in this major change is provided in Appendix B.

The initial adoption of Lean strategy was successful and operational results improved significantly. Within six months, the unit's production lead time fell from 57 to 23 days, and machine utilisation was raised from 80% up to 95%. In some cases, machines were utilised above 100% i.e., utilisation exceeded machines owners' expectations. In addition, the unit benefited from better quality, as low levels of inventory revealed quality problems earlier (when products reached downstream units), and thus enabled earlier repairs.

After a few months of successful Lean practicing, the implementation team left the unit. However, without the supervision of the implementation team, the unit gradually returned to its traditional practices. The implementation team was called back into the unit and attempted to reinforce the changes that supported Lean practices. This attempt was not sustained this time, as the unit's top manager was promoted (ironically, due to the successful results achieved by implementing Lean strategy in the mill), and the new top manager did not support the methods and practices of Lean strategy. After abandoning Lean practices, lead times climbed up to 90 days, and the mill's performance deteriorated. Eventually, the mill was declared non-economical and was closed down[1]. The equipment was sold, and many of the employees were let go. The events of this case study are summarised in the timeline presented in Figure 4.2.

[1] In addition to the increase in production lead-times, there is evidence that suggest the closing of the mill was influenced by additional political and economic factors. However, there was a significant capital investment in new equipment, which was meant to upgrade the mill's technical performance, indicating that major efforts were exerted to sustain the mill. The role of other factors in the shutdown was inconclusive, and not the primary concern of this study.

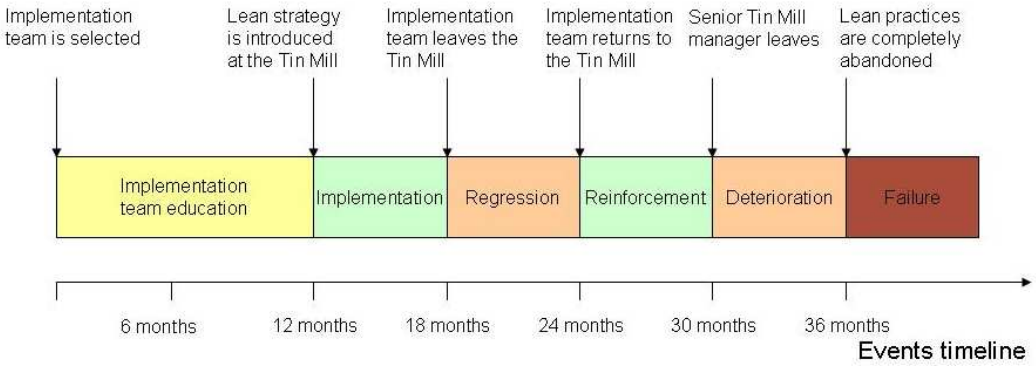

Figure 4.2: Timeline for Lean implementation at the mill

4.3 Current scheduling

Current scheduling was studied in two different units: Unit A and Unit B (Figure 4.1). Unit A is a metallic painting and coating facility, providing supplies for building, construction, manufacturing, automotive, and transport. The unit receives its raw material from a mill upstream.

Unit B rolls steel slabs into flat products used in manufacturing, building, construction, and mining. The capacity of this unit is relatively low. However, their products have the highest profitability. Thus, this unit has the highest priority for feed material from upstream units. The sequence of scheduling is constrained by process requirements, prescribing a certain sequence of product types.

Current scheduling is based on strategic and sales plan. Planners are informed of the strategic plan for the next three years and of the sales plan for the next year in meetings with higher management. The planners then pass the relevant information to the master schedulers. The master schedulers supervise the unit schedulers, who produce the daily plan. Finally, shift controllers are in charge of moving raw material, work-in-process, and finished product around the plant. Table 4.1 summarises this scheduling hierarchy.

Table 4.1: Scheduling hierarchy			
Scheduling level	**Time horizon**	**Time units**	**Scheduling function**
Strategic Plan	3 Fiscal years	Quarters	Planner
Sales and Operations Plan	1 Fiscal year	Months	
Master Production Schedule	3 Months	Weeks	Master Scheduler
Production Plan	1 Week	Daily	Unit Scheduler
Production Schedule	2 Days	Hourly	
Control – Schedule Execution	1 Shift	Minutes	Shift controller

The scheduling process at both units aims to satisfy customer orders on time while maintaining full capacity utilisation. However, the two units differ in their control over the functions surrounding the production process. Unit A does not have formal control over its suppliers, sales, and logistics, while Unit B formally controls them. Unit A planners and schedulers rely on communication and collaboration with their surrounding functions, whereas Unit B coordinates the surrounding functions through formal control. To assure appropriate supply, the scheduler at Unit B informs the supplier unit of the type of raw material needed for the following days. The planner at Unit B informs the sales team of the capacity that they are permitted to sell over the following week. Finally, logistics and transportation are informed of the due dates and special delivery needs (as some products require special vessels).

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Chapter 5 Findings

An analysis of the data collected from the case studies as described in Section 3.3 revealed various themes that address the research questions. These themes describe the various roles of schedulers in this organisation, the various factors that influence their performance of Lean practices, and the influence of assumptions shared by organisational members on the adoption of Lean practices. This chapter integrates themes that emerged from the implementation case study and from the current scheduling practices of the organisation studied, and addresses the research questions in the following manner: Section 5.1 addresses the first research sub-question, which seeks to compare the role of the schedulers in the steel industry with previously described roles of schedulers, and presents the roles of schedulers identified in this study.

Section 5.2 addresses the second research sub-question, which seeks to identify and describe various factors that support or impede the adoption of Lean scheduling practices. This section presents evidence of individual factors: emotional skills, motivators, and intuition; contextual factors, including unit localised or collaborative focus, prioritisation of customer needs or production, and performance measures; and finally, task-related factors: priority for low or high inventory, prioritisation of orders, and process requirements.

Finally, in relation to the third research sub-question, Section 5.3 addresses the third research sub-question, presenting the assumptions shared amongst organisational members that support or impede the successful and sustainable adoption of Lean strategy. Section 5.3 provides a detailed examination of how factors identified in

Section 5.2 are synthesised into these shared assumptions. However, a relation of the assumptions to Lean principles is discussed in Section 6.3.

5.1 Roles of schedulers in the steel industry

This section addresses the first research sub-question: "*How does the role of schedulers in the steel industry compare with schedulers' previously described roles?*" As described in Table 4.1, four levels of schedulers have been identified in the organisation: planner, master scheduler, unit scheduler, and shift controller. While planners and shift controllers are identical terms and roles to those described in literature, master schedulers and unit schedulers differ slightly. The term "schedulers" found in literature describes a role which is equivalent to master schedulers in the organisation in this study (Fransoo & Rutten 1994; MacCarthy & Wilson 2001; Jackson, Wilson & MacCarthy 2004). However, this organisation also includes unit schedulers, who were not previously described in literature: this seems to be an intermediate level between "scheduler" and "controller", which only schedules specific areas in the plant, in accordance with the instructions of the master scheduler. Partial evidence indicates that master schedulers perform the roles described in literature (i.e., information node, influencer and negotiator, and problem anticipator and solver). However, in addition to these roles, evidence suggests that master schedulers also influence the execution of a strategy. This section presents this evidence.

5.1.1 Information node

In accordance with previous literature, master schedulers in this organisation (1) receive current information from various sources, (2) act as sources of real-time information, and (3) manipulate information by seeking ways to improve its reliability

and quality. These behaviours are discussed next. Evidence for these functions are summarised in Table 5.1.

Table 5.1: Evidence of schedulers' actions as information nodes

Information provision to the scheduler	[Our scheduling team] is the hub of all knowledge, and we are lucky that everyone recognises that. [They are aware that] "if I do something that might affect supply chain, I'd better tell them [the scheduling team]". [Lee, planner and scheduler, Unit A]
Seeking information from the scheduler	Fred [the master scheduler] has a really good picture on everything. Everyone speaks to him, so he's a good man to channel [information] through. [Ronald, shift controller, Unit A]
Information manipulation and interpretation	Our challenge was to get a correct capacity promise. [Production] now cannot promise any more than what they have made for the last 13 weeks. It is called "demonstrated capacity". You have only been demonstrating for the last 13 weeks X amount of tonnes, therefore you can only promise X amount of tonnes. [Lee, planner and scheduler, Unit A]

(1) **Information provision to the master scheduler**

Master schedulers are recognised by the various organisational functions as central nodes coordinating the plant's operations. For this reason, master schedulers are kept informed about the situation of the plant in terms of machines, transportation, and production status. These master schedulers testify that they are sufficiently informed and updated to perform their duties in this organisation.

(2) **The master scheduler as a source of real-time information**

Master schedulers serve as a source of real-time and up-to-date information. This is evident from that fact that various functions (e.g., the controller in the quote)

acknowledge the master scheduler is current and up-to-date in the state of the plant, and thus is a reliable source.

(3) **Seeking ways to improve information quality**

Master schedulers receive information from various sources; however, they do not blindly accept that information. Rather, master schedulers seek to interpret and make sense of that information in order to verify that it is correct. Incorrect information severely harms scheduling decisions, and therefore master schedulers seek standardised ways to address consistent problems of incorrect information. For example, due to the master schedulers' initiative, a new rule has been introduced regarding the estimations of capacity. Master schedulers compose production schedules based on estimated capacity. This estimate is provided by production managers. However, inflated promised capacity presents potential disruptions to future schedules. Therefore, the schedulers introduced the concept "demonstrated capacity", production capacity that has previously been demonstrated by tangible production outcomes. This is the upper limit of capacity that production can now promise to produce. The upper limit prevents production functions from inflating their predictions of future production capacity, and provides master schedulers with information they find more reliable.

5.1.2 Influencer and negotiator

Master schedulers are required to enact the production schedule; however, they often do not have formal authority over the different functions of production, maintenance, or sales, as evident in these quotes:

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You can develop the best plan in your head, [but] you don't
own the line and you don't have any direct control over
lines.  You have sell it to someone and get them to sign
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off on something weird with this line, [like] stop a line. [Fred, master scheduler, Unit A]

We work with a lot of production people. [As a scheduler,] you certainly have to interact well with them, because they're not reporting to you. [Owen, master scheduler, Unit B]

These functions often have conflicting interests and agenda. Synchronising their activities can be challenging. In addition, difficult and non-collaborative individuals, particularly in the production function, often forcefully advance their own agenda:

A lot of our [production] managers use their bullying tactic a lot. They come in loud, they come in aggressive. That is how they get things done. [Fred, master scheduler, Unit A]

You've got some people that just wake up in the morning and say, "I'll make it hard today for anybody that I talk to". And it's generally what they do. [Ronald, shift controller, Unit A]

Schedulers use three different mechanisms to influence and negotiate with the conflicting parties: (1) building relationships, (2), personal convincing tactics, and (3) implicit authority. Evidence of these mechanisms is presented in Table 5.2.

Table 5.2: Evidence of schedulers' actions as influencers and negotiators

Relationships	I can show you in here, the crane driver's personal phone numbers. It's got the names of their children next to them, so every time they phone up, I can say, "how's Alex, how's Heidi". Just to build that rapport, because ***down the track when I need something done, they will do it for me*** where they wouldn't do it for other people. [Paul, unit scheduler, Unit A]
	We are lucky ***we have really good relationships***. Our team has a ***very good relationship with all of the units***, with people on our same level. [Lee, Planner and Scheduler, Unit A]
	Part of this role is that ***you really need that relationship stuff*** with someone you need to influence [Fred, master scheduler, Unit A]

Personal convincing tactics	[Convincing tactics] ***depend on the person.*** Some people need lots of data and time to digest that, others don't, but it is just ***dealing with that person's personality type traits*** to get the outcome you want. [Fred, master scheduler, Unit A]
Implicit authority	We give the schedule to the slab yard and the slab yard ***has to*** collate the schedule. That means they have got their crane and they are digging all their slabs that I have put on schedule. It might be at the bottom of the stack and ***they have to*** dig it out. [Vera, unit scheduler, Unit B]

(1) Relationships

Some schedulers placed a great deal of emphasis on building relationships. They expend time and effort building relationships and creating rapport with colleagues from other functions to establish collateral for future negotiations and requests.

(2) Personal convincing tactics

The master scheduler in Unit A explained that he uses reasoning to convince individuals, and that he tailors his argument based on the other party's personality. The level of detail and the time a person needs to get used to the idea that the scheduler puts forward depends on the individual who needs to be convinced, and the scheduler not only is aware of these differences, but also addresses them in his negotiation technique.

(3) Implicit authority

In Unit B, however, relationships did not seem to play as much of an important role as in Unit A. Despite testimonies of relationship with production functions, the schedulers' influence is derived from the organisational norm, which accepts the schedulers' implicit authority. The scheduler described in a factual manner how she provides directions to the slab yard, and how they have to follow these directions.

5.1.3 Problem anticipator and solver

Schedulers foresee problems in terms of production continuity, achievements of goals, and performance measures. These problems are either prevented, or addressed and minimised before they arise. When unexpected problems occur, schedulers seek various ways of addressing them. Schedulers are familiar with several avenues, or "levers", to address a problem. Table 5.3 presents findings that demonstrate this role of the scheduler.

Table 5.3: Evidence of schedulers' actions as problem anticipators and solvers

Problem anticipator	When I want to put a plan together, [I look at] what can go wrong, and how am I going to deal with it. [Fred, master scheduler, Unit A] By deciding to go one way, you might impact on another unit, or something that you're going to have to spend more time with later, so you obviously you don't go that way, or minimise the impact to it, at least. The biggest thing I worry about is cranes breaking down, machinery breaking down. As soon as I hear something's suss, straight away I'm looking for avenues, which way can I go [to overcome the problem]. If it does happen, and generally 99% of the time it does happen within an hour, I'm all right, 'cause I'm an hour ahead. [Ronald, shift controller, Unit A]
Problem solver	[Levers are] usually about pushing export out or in, that is one lever that you can use. Recommending that we cut domestic demand, that's another lever. If we have too much inventory, we can recommend stopping a unit. There is point-of-production change as well: I can get another site to help me make my orders. [Lee, planner and scheduler, Unit A

The first quotes show that schedulers and controllers are constantly looking for potential problems in an attempt to anticipate them, and prepare solutions for them in advance.

The last quote demonstrates that in their role as problem solvers, the schedulers may take various actions (or "levers") in order to resolve a problem. One lever is modifying the amount sold as export. Domestic orders can be prioritised over export, and thus capacity can be used primarily to address domestic rather than export orders. In contrast, excess inventory can be released to export, thus reducing inventory levels. Another way to reduce, or avoid excess, inventory levels is by stopping production. If demand exceeds supply, schedulers can also restrict future demand by setting the quantities that customer service teams are allowed to sell. And finally, another way to address excess demand is by getting products produced in another plant.

5.1.4 Strategy executor

In addition to the schedulers' roles already described, in this organisation the schedulers are central to the successful execution of production strategy. This centrality of the schedulers was pointed out by the director of the program to implement Lean strategy, who since then has managed several organisational changes in the same organisation. Thus, his reflections and insights were heavily weighted when identifying the roles that are central to the adoption of Lean strategy. His view on the role of schedulers is shown in this quote:

[Successful changes here are] run from the middle. These [large] companies are managed from the middle. The people that would make Lean happen, they are typically master schedulers and the level below them. I think they are the key. [If you find] common ground with them, it will work for sure. [Otherwise], as soon as their boss loses

interest [in Lean] or their boss moves, it's going to struggle. [Cameron, program director, the mill]

Cameron is referring to the need to gain schedulers' support for and agreement to Lean strategy, as they have the power to "run" the large organisation studied. He sees them as central to the sustainability of Lean strategy as long as they intrinsically agree with the strategy, and are not driven by the authority of their boss.

This view was supported by other members of the implementation team, when schedulers were referred to as part of middle management. Schedulers, as part of middle management, were at the same time the most important, and the most difficult, group to convince, as demonstrated by the following quotes:

It's the middle. It's convincing the people who had to make it happen… that was our hardest group of people to convince. [Vincent, project manager, the mill]

The biggest problem was middle management. Middle management hated to see any unit stop… they didn't like it. [Ross, program sponsor, the mill]

Further evidence that schedulers are key individuals who enact a strategy is seen when this strategy is explained to the master scheduler, an explanation that comes from the planner.

Once we [management] have made the decision at the master planning (MPS) level, I take the outputs, [the] document that says "this is what we should run" and talk with the master scheduler. I make sure that he understands the direction for him, and the reasons why we have to stop [production] line - because we are making too much inventory and it will blow the budget, for example. [Lee, planner and scheduler, Unit A]

The master scheduler must to understand the overall strategy and the "big picture", as the master scheduler has an influence on how targets are achieved. The fact that higher management and the planner dedicate time to routinely brief the scheduler

and explain the underlying reasoning behind decisions indicates that the scheduler's understanding of the strategy is important.

Another indication of the role of the scheduler as a strategy executor is the schedulers' confidence that they can achieve targets dictated to them by the planner, and the degree of freedom to achieve the targets:

[If] the [planning schedule] says you should be able to achieve it - make it happen [Fred, master scheduler, Unit A]

These quotes show that schedulers are responsible for enacting the goals set by higher management levels. The planner communicates production objectives that are set on an aggregated level by the plant's management. Schedulers then translate these objectives into daily operations. Often, the aggregated level does not take into account the low-level operational constraints, such as changeover rules, maintenance problems, and urgent orders. The scheduler, who maintains an overview of the plant's current state in terms of resources and constraints, is required to understand the strategy and the operational implications derived from it in order to execute it.

To execute a business strategy and achieve targets required, schedulers use "levers", described in Section 5.1.3. The choice to use a lever and the choice of which lever affect the alignment with the strategy. For example, one lever described is making a recommendation to stop production in order to avoid a high inventory level. Using this lever supports Lean principles. However, schedulers may also export excess inventory for a lower cost to relieve inventory levels. This practice is not as closely aligned with Lean principles, since it encourages overproduction (i.e., production beyond requested amount).

This role differs from the role of problem solver and anticipator, as the schedulers do not solely anticipate and solve problems relating to the schedule, but also problems in achieving the strategy prescribed by higher management.

Current schedulers were not actively concerned with executing Lean practices, such as reduction of batch sizes and reduction of inventory. Rather, the schedulers were focused on achieving their targets, with no reference to whether their actions are aligned with Lean strategy. This is no different to the pressures that led schedulers to reject Lean strategy when it was implemented in the mill. This pressure to meet production targets was one of the key inhibitors to the adoption of Lean scheduling practices; this aspect is further discussed in Section 5.2.1.2-3, which addresses the second research sub-question.

5.1.5 Summary

The analysis in this section provides partial evidence that the roles of schedulers described in the literature – information node, negotiator and influencer, and problem anticipator and solver – are relevant to the studied organisations. In addition, the analysis in this section described another role schedulers play in the organisation: strategy executors. The analysis shows that the schedulers' decision-making is crucial to the successful execution of a production strategy defined at the higher management levels.

In addition, the analysis reveals that the schedulers in this industry play an important role when Lean strategy is implemented, enacted, and sustained. Schedulers decisions are central to production and manufacturing operations in the organisation, and are able to sustain (or in this case, cause the failure of) the sustainability of Lean strategy. This role of the scheduler as a strategy executor was not previously described

in the literature; however, this study demonstrates that it is critical to the sustainability of Lean strategy in the steel industry.

5.2 Factors influencing Lean practices

This section addresses the second research sub-question: "*What factors (individual, task, and contextual) support or impede the adoption of Lean scheduling practices in the steel industry?*". A thematic analysis of interview transcripts and organisational documents revealed a range of individual, contextual, and task-related factors that support or impede Lean practices. The analysis was guided by the factors identified in Chapter 2, summarised in Table 2.2. Individual factors highlight the importance of schedulers' emotions and attitudes. Contextual factors take into account unit performance measures and shared assumptions in the organisation. Task-related factors take into account production-process requirements and scheduling objectives. These factors are summarised in Table 5.4. For each category (individual, context, and task), factors supporting Lean practices are presented first, followed by factors impeding them.

Table 5.4: Factors influencing Lean scheduling practices

	Supporting Lean practices	Impeding Lean practices
Individual	▪ Schedulers' emotional skills	▪ Expected emotions ▪ Attitudes
Context	▪ Collaborative focus ▪ Awareness of preventive maintenance ▪ Prioritisation of customer needs ▪ Low focus on production	▪ Quarterly measures of inventory ▪ Overselling ▪ Localised performance measures ▪ Shared resistance to stopping machines

Task	▪ Avoiding double handling ▪ Preference for orders over forecasts ▪ Preference for low inventory	▪ Need for high utilisation ▪ Inventory as means of delivery ▪ Inventory as buffer

5.2.1 Individual factors

The individual factors identified in this study as influencing schedulers' adoption of Lean strategy involved significant emotional aspects. The schedulers' ability to manage their own emotions enables them to withstand the pressures to deviate from enacting a strategy. Two other individual factors were found to impede schedulers' enactment of Lean practices: expected emotions and attitudes.

5.2.1.1 Supporting: Schedulers' emotional skills

Schedulers in this organisation are subjected to negative feedback that results in negative emotions. However, the schedulers contend that anticipated negative emotions do not influence their scheduling decisions. They do, however, attempt to minimise the chances of occurrence of such negative emotions by communicating with parties that may be the source of negative feedback. But ultimately, schedulers make decisions that in their view are best for the business, in spite of the negative anticipated emotions.

The quote below explains how the last days of the week are more difficult for the scheduler, as on these days the schedule has to be changed to fit the demands of the weekend. The operators respond in an unfavourable way to changes required in the schedule. The scheduler, however, does not avoid decisions that lead to such negative feedback, as the scheduler views these decisions as necessary.

> Thursday-Friday are the hell of my job, I get abused every time. Thursdays-Fridays are always [about] setting yourself up for the weekend, because you can only have a

certain type of material on the weekend. [Vera, unit scheduler, Unit B]

The second quote demonstrates the importance of schedulers' ability to manage their own emotions. The planner in this quote explains that when this ability is not developed, a scheduler can end up prioritising the wrong organisational function, because of the emotions they evoke:

A novice could make the mistake of listening to the [production] manager rather than the customer [service] manager. [When] you are a novice, you don't have the confidence in your decisions, so you listen to the person yelling the loudest or making the most noise. [The mistake here] would be bending to whoever is yelling at you the most. [Lee, planner and scheduler, Unit A]

The planner explains in this quote that prioritising one organisational function over another can happen due to an emotional response. When a manager in one organisation function (in this example, a production manager) uses aggression to pressure the scheduler, the scheduler may seek to avoid negative emotions by complying with the aggressor's demands.

These quotes indicate that schedulers' ability to manage their own emotions in the face of pressures applied through negative feedback is important. Schedulers regularly draw on this ability in order to successfully perform their role. Other emotional aspects, which impede schedulers' adoption of Lean practices, are presented next.

5.2.1.2 Impeding: Expected emotions

During the implementation of Lean strategy, two types of expected emotions led schedulers to reject Lean practices: negative and positive. Schedulers expected negative emotions as a result of following Lean practices, such as changeovers and inventory

reduction. In addition, schedulers expected positive emotions as a result of achieving traditional goals such a high production volume.

Negative expected emotions: fear and regret

Schedulers consistently resisted stopping production when Lean strategy was implemented. This resistance is demonstrated in the following quotes:

> [Schedulers in] middle management hated to see any unit stop… they didn't like it.[Ross, Project sponsor, the mill]

> When Lean first goes in, people run up against kanbans and have to stop. It becomes very stop-start, which is a big fear. [Cameron, program director, the mill]

These quotes demonstrate the persistent nature of resistance to the need to stop production due to kanbans, and the emotional aspect driving this resistance. Individual emotions (like fear of machine breakdown) were motivating schedulers to reject Lean scheduling practices. Schedulers anticipated regret for stopping production due to equipment unreliability and pressure to produce large quantities. These reasons are summarised in Table 5.5.

Table 5.5: Expected negative emotions resulting from Lean practices

Unreliable equipment	There's certainly a view that the plant is going to break soon, so you might as well make the most of it while you can. Because ***it is going to be broken tomorrow, and then we'll need what we made today.*** If you don't make it now, you're wasting an opportunity. That's driven by a culture of unreliable equipment. It's very hard to break that down 'cause there are elements of truth in it. After breakdowns, they'd [schedulers] say: "***If we'd just run through that kanban and went a bit longer, we might have been all right.***" [Cameron, program director, the mill]

Pressure to produce large quantities	***Schedulers knew that they were going to be held responsible*** for production [levels]. They were thinking "I've got to produce a bit extra, I've got to put a bit extra stock there". That would have ruled the day. That's the thing that gets us money in the bank. [Vincent, project manager, the mill]

The first quote shows how schedulers' expected regret led to resistance to Lean strategy. This quote demonstrates that machine breakdowns during the implementation of Lean strategy reinforced the view that producing and holding safety stock is a better strategy for the plant, due to its unreliable equipment. Schedulers experienced regret over acting according to Lean practices and deviating from the status quo.

It is important to stress that stopping a producing line did not necessarily mean stopping production altogether. If a line had to be stopped due to a full kanban, the unit was allowed to switch to a different product (thus engage in a changeover), or slow down current production. These options mean either maintaining production quantities or avoid changeover. However, the options were considered to be less desirable than overproduction.

The second quote shows that pressure to achieve production targets was prioritised over other considerations. A constant pressure to produce and meet production targets was overriding other rules, such as adherence to inventory levels, and led to production that was not aligned with Lean principles. This pressure also relates to the counter-intuitive nature of Lean strategy, discussed in the next section.

In addition to negative expected emotions, schedulers could expect positive emotions as a result of achieving "a production record":

They ***feel good*** when they produce the lot: There's a thing around here they call "production records" - who's made the most tonnes in a shift. It's a big thing when someone sets a new record [Ian, team leader, the mill]

Production records still influence scheduling decisions in this organisation, as described by a current master scheduler:

Not long ago we spent a week and a half trying [to get a production manager] to stop a line. He wanted it to keep running, because in a week and a half he got a yearly production record. I [let] him [have] his yearly production record, so he will then stop. [Fred, master scheduler, Unit A]

Lean strategy requires that production levels do not exceed customer orders. This requirement contradicts the goals of many production managers, as explained by the following quote:

A lot of people want to achieve individually. They want compete, they want to 'climb a mountain', they want to outdo people, that's what drives them… slowing down your mountain climbing to help the overall community was of no benefit to you at all. They're rewarded to set a record - either financially or career-wise, or even just interpersonally. Setting a record is a very big thing in this culture. [Cameron, program director, the mill]

This type of goal, driven by positive expected emotions, counters one of the basic requirements of Lean strategy – synchronising production along the entire supply chain. This perhaps was the most persistent source of rejection of Lean strategy, as organisational feedback is consistent with this goal. Financial rewards for production managers are still based on their production quantities. In addition, production of large quantities is further rewarded professionally, through promotions, and socially, through the responses of other organisational members.

Production managers were seen as the ultimate authority in the business, and the success of the unit was also seen as the success of the master scheduler. Their

motivation to compete and produce large quantities was very difficult to counter, when the proposed strategy did not allow for competition and record-setting.

5.2.1.3 Impeding: Negative attitudes towards Lean practices

The implementation team suggested schedulers, as well as other organisational members, had negative attitudes towards Lean practices (i.e., small batches, frequent changeovers, and low inventory levels). Similarly, current schedulers demonstrated that this negative attitude is still present to a certain extent.

First, this section presents attitudes towards Lean practices evident during the implementation of Lean strategy. These negative attitudes are evident in three aspects: (1) intuition regarding Lean practices, (2) belief in the value of Lean practices, and (3) learning over time.

(1) Intuition

The implementation team expected a negative attitude towards Lean practices. Therefore, an illustrative game was included in the educational workshop on the principles of Lean strategy, provided to managers. Section 4.2 describes the implementation process of Lean strategy in the mill, and further elaboration on this process and the educational workshop can be found in Appendix B. The illustrative game, called "paper houses" game, was designed to illustrate and provide experience with the difference in outcomes between "push" and "pull" strategies. Participants in this game aim to produce as many "paper houses" as possible within a given time frame. This game was first played using "push" strategy, where each echelon attempts to produce as much as it can. The game was then played a second time, this time using a "pull" strategy. Under "pull" strategy, each echelon responds only to the demand

generated by its customer echelon. Performance, both in terms of throughput and product diversity, clearly illustrated the superiority of a "pull" strategy, hence providing tangible evidence to the superiority of Lean strategy over the traditional production strategy (this point is further elaborated in Appendix B, Section B). However, this result contradicted intuitive production practices that the participants were accustomed to. The outcomes of this game were not sufficient to change the participants' mindset, as demonstrated by the following quotes:

> It's counter-intuitive to people - how could slowing down be better? People find that difficult to believe because it's counter-intuitive. [Cameron, program director, the mill]

> They [schedulers] understood the logic of it. They understood the rationale of it, although many of them said "It's counter intuitive to me. I can see how it's working but it's still counter intuitive to me, it still doesn't make sense compared to my old paradigm" [Ross, program sponsor, the mill]

The immediate and automatic response of schedulers and production managers to Lean practices was negative, and they rejected Lean practices. Paced production with small batches was rejected by participants, as it did not match their intuitive evaluation of these practices. This indicates that the rejection of Lean strategy sprang from their intuitive system, rather than from a rational evaluation of the strategy.

(2) Belief

Another indication of negative attitudes is the evident belief that Lean practices are not beneficial to business success. A member of the implementation team explains how this belief (or rather, this *dis*belief) became evident when top management changed and Lean practices were no longer enforced:

There was an undeniable feeling that they [middle managers] never really *believed* that Lean was good for business. I think most of them wanted to do a good job, and they *believed* that doing a good job is measured by how much output they produce each shift. [Ian, team leader]

The speaker indicates not only that there was a belief that Lean practices were not good for the business, but also that there was a belief that production in large quantities is beneficial.

(3) Learning over time

This negative attitude towards Lean practices (and positive attitude towards high production volume) develops over time. The next quote indicates how production managers acquire these attitudes, through experience. It describes how production managers were reluctant to adopt a positive view of Lean practices when Lean strategy was implemented. After the implementation, the reduction of batch sizes and inventory levels resulted in positive outcomes, such as early detection of quality problems, and shorter lead times. However, production managers were reluctant to attribute these positive outcomes to Lean practices:

They [production managers] were very reluctant to relate all those improvement effects to this inventory reduction. The operating guys have got where they are by running their mills hard, so when the going gets tough they just go back to that: they run their mills hard and to hell with the inventory: "just for a month we're going to go back to this old thing. We know it works". [Ron, team leader, the mill]

When this implementation took place, production was seen as the most important part of the business. Anything that results in successful production was regarded as positive, and disrupting production was seen as risky and harmful. Therefore, it is highly likely that the attitudes of production managers dominated amongst other organisational members, such as schedulers.

In addition to evidence of past negative attitudes towards Lean practices, some evidence suggested current schedulers still have a somewhat negative attitude towards Lean practices, such as many changeovers and low inventory levels. First, the scheduler negatively refers to the constant requirement to reduce inventory. Second, a scheduler explains that a good schedule minimises the number of changeovers, as each changeover carries a risk to future product quality.

Stupidly, the business squeezes you: can you drop your inventory a little bit more, can you drop it a little more [Lee, planner and scheduler, Unit A]

The reduction of inventory is clearly seen by the scheduler in this quote as a negative step to take.

When you schedule, you have to do the best you can to minimise [changeovers] because every changeover could affect product quality. After a changeover, it can take up to three runs to get the right quality. By the time they get it right, you might have already run three to four tonnes. If you think $1300 per tonne, that's about $6,000 lost in one run. If I double the number of changeovers from five to 20, that is a lot of money [Sam, unit scheduler, Unit A]

The scheduler in this quote explains why changeovers should be avoided: quality after a changeover cannot be guaranteed, and may result in defects. Producing defects is seen as a three-fold loss: loss of raw material, loss of processing time, and loss of the new material that would be needed to replace the defective run.

The role of attitudes in scheduling decisions has not been previously addressed in scheduling literature. These aspects are discussed in Section 6.2.

5.2.2 Contextual factors

Contextual factors shape the environment in which scheduling is performed, and therefore determine how conducive the environment is to Lean scheduling. Contextual

factors found to support Lean scheduling practices are collaborative focus, awareness of preventive maintenance, awareness of customer needs, prioritisation of customer needs, and a low focus on the demands of production. Contextual factors found to impede Lean scheduling practices are quarterly measures of inventory, overselling, localised performance measures, and shared resistance to stopping machines.

5.2.2.1 Supporting: Collaborative focus

A collaborative environment surrounding the schedulers supports their coordination of resources and activities. Unit A consciously emphasised the importance of collaboration, explaining that it enables the synchronisation of goals and effort between the various functions, increases cross-functional awareness of possible issues and impacts, and enables superior decision-making. This importance is demonstrated in the following quotes:

> Our team is successful because we hire people [who have] soft skills, good influencing skills and a fairly good level of interpersonal savvy. I will choose someone that has those skills over someone with [domain-specific] knowledge. [Lee, planner and scheduler, Unit A]

> I am a big fan of ringing up and chatting to someone too. Part of this role is that you really need a relationship with someone you need to influence, and you can't do that via email.

> I really needed their input [customer service]. There is a lot of things they can do with orders: referring to customers, talking, calling [and accepting an order as] "complete". That really helps improve your delivery performance and it makes you not waste capacity. You can make exactly what you need.

> [Fred, master scheduler, Unit A]

These quotes show the emphasis placed on relationships in Unit A through selection of employees for the scheduling team, the preference of communications

methods that support relationships, and an example of the benefits of such relationships with the customer-service function. This focus on collaboration contributes to the unit's effectiveness and its performance. Effectively addressing customer needs reduces unnecessary inventory, and thus supports Lean practices. Establishing relationships with parties involved in the production process supports Lean practices, as these relationships enable synchronisation of the efforts of various organisational functions.

5.2.2.2 Supporting: Prioritisation of customer needs

Prioritising customer needs across functions (including production managers) counters the influence to produce high quantities. When schedulers need to make decisions that do not cater for production's goals (i.e., high throughput and high production volume), they need to justify these decisions. When timely delivery is acknowledged across functions as important, and accepted as important by production managers as well, it is an acceptable justification. This enables schedulers to make decisions that align with Lean strategy. Evidence of this counter-influence is presented in Table 5.6.

Table 5.6: Demonstrating awareness of customer needs

Awareness of customer needs as opposed to production demands	There is a lot more focus on delivery performance [DP], a lot more recognition from the [production] unit [and] the operations managers, that DP is an important thing and that sometimes we might have to stop our line to get to delivery performance. That's helpful, especially when I did say that the priority is DP and it is reflected in those behaviours. Still not very good, to stop a line, but there is an understanding. [Lee, planner and scheduler, Unit A]

The scheduler refers to "delivery performance", which is a measure of timely delivery used in the organisation. This measure compares orders that were dispatched on time to arrive at the customer's requested date, and the orders sent later than that. The scheduler indicates that although stopping production is seen as a negative step, it is more acceptable if it contributes to timely delivery. The scheduler indicates that production units are *understanding* of the need to achieve timely delivery, and the fact that it may come at the expense of their own performance.

5.2.2.3 Supporting: Awareness of preventive maintenance

One of the important supporting functions of Lean strategy is preventive maintenance. By scheduling maintenance and embedding it into mandatory procedures, maintenance is routinely performed and minimises breakdowns. In addition, preventive maintenance initiatives when breakdowns appear possible can prevent them, and the accompanying lengthy downtimes, as demonstrated in Table 5.7.

Table 5.7: Evidence of preventative maintenance

Planned preventive maintenance	Planned maintenances, which are on each unit, are every six weeks or so [Lee, planner and master scheduler, Unit A] Generally their maintenances start on time [Fred, master scheduler, Unit A]
Unplanned preventive maintenance	For instance, our automatic crane - if it starts playing up before it gets to 3 o'clock, I make sure I get three or four technicians over there to help the nightshift bloke through nightshift. There's no point leaving him to try and source people 'cause there's no-one here through the middle of the night. So I'll source the people over before they go home, try and get something done with it, and then hopefully for the next 24 hours, the problems are deleted. That helps me out, helps him out, and the company. [Ronald, shift controller,

Unit A]

Preventive maintenance is central to continuous and predictable performance that Lean strategy requires, and therefore practices of consistent scheduled maintenance as well as preventive maintenance are necessary. Scheduled maintenance is adhered because it is included in the planned schedule. In addition, the shift controller explains that he seeks preventive maintenance if there is an indication equipment may break down. This initiative prevents downtime during night shift, when corrective maintenance cannot be performed.

5.2.2.4 Supporting: Low focus on the demands of production managers

Production managers strongly resisted Lean practices when Lean strategy was implemented (Section 5.2.1.2). In this organisation, production managers are mainly interested in achieving high volume and throughput. They view schedules that do not cater for this aim unfavourably. In the past, this priority of maximising production levels, capacity utilisation, and throughput was shared by the entire organisation (Sections 5.2.1.2 - 4). However, at present, although this need to produce high quantities is understood and respected, it no longer dominates scheduling priorities. Quotes supporting this view are presented in Table 5.8.

Table 5.8: Demonstrating low focus on production

Low focus on the demands of production managers	I just say: "you will run what we need to run", and sometimes they say: "come on, what the hell, we need some tonnes!"…[but in the end,] production is there to do what I ask them to do, or produce what I ask them to produce. [Sam, unit scheduler, Unit A]
	They all [production managers]bitch and whinge: "why are we doing this?" [changing over or stopping a line], because they want to keep it going, and yet we are going to stop [the line].

[Fred, master scheduler, Unit A]

5.2.2.5 Impeding: Inventory levels measured quarterly only

The infrequent measurement of inventory levels supports the practice of maintaining high inventory. Inventory levels are only measured quarterly, and therefore they can exceed their limits during the rest of the time, as presented in this quote:

Inventory - the focus is on it only four times a year. [Only] at the end of each quarter, [we ask]: "have we met our inventory target?". [Lee, planner and master scheduler, Unit A]

This condition may actually exacerbate variability along the supply chain, as during certain periods production will be lowered to reduce inventory. Lean strategy seeks to create stable and predictable patterns along the supply chain: the variability resulting from relatively infrequent monitoring of inventory counters Lean practices.

5.2.2.6 Impeding: Overselling

One of the worst sins, according to Lean strategy, is to commit to selling more than the plant can produce. This practice goes against basic common sense, as it inherently leads to excessive demand on production and delivery delays. Overselling creates greater urgency to produce large quantities and maximise capacity utilisation. Two underlying motivations support this practice: (1) the sales unit's incentives and performance measures, which are based on quantities sold, and (2) the need to accept domestic orders as a way to maintain domestic customers rather than lose them to foreign markets. Table 5.9 presents evidence for these motivations.

Table 5.9: Evidence of overselling practices	
The sales unit motivated by sales figures and not aware of inventory reduction	Salesmen don't care about inventory. That's the supply chain. Salesmen don't care. All they care about is money. [Cameron, program director, the mill]
Not restricting domestic orders	[Restricting domestic orders] is a concept that we have never had in [this organisation]. Every order we just say: "thank you, bring it on", even though we know we are overloaded. [Lee, planner and master scheduler, Unit A] Our business has always been one of we will never knock back a domestic order, so we just take orders, way more than we are producing [Fred, master scheduler, Unit A]

Overselling provides justification for overproduction. The acceptance of overproduction is also demonstrated in periodic reports sent to all department managers. A quarterly report includes a graph of production quantities for each business unit against target quantities. When the production is below targets, a bubble explaining the reason for the shortage appears, typically describing a major breakdown event. However, when production amounts are above targets, no explanation is provided. This demonstrates that failing to meet production target is viewed as something that requires a satisfactory explanation, whereas overproduction is acceptable, if not supported. This is in contrast to one of the main principles of Lean strategy – elimination of overproduction. From a Lean perspective, production levels that are above target warrant an explanation just as much as below.

Overselling reduces schedulers' belief that timely delivery can be achieved at all, and provides a reasonable justification in schedulers' minds for large batches and high

production quantities. For this reason, overselling works against the adoption of Lean practices.

5.2.2.7 Impeding: Localised performance measures

In this organisation, performance measures must be directly related to the ability of the performer to control the measured outcome. For this reason, production managers are not measured on delivery performance, as that depends on functions that exceed their influence, such as downstream production, dispatch, and delivery.

The need to measure performance that depends only on the individual's area of responsibility prevents measuring performance that depends on collaborative efforts. Production levels remain the main measurement of production managers' performance. However, this measurement, which is based on core competencies, leads to reduced collaborative effort on the part of production managers.

> The scheduling team often invites them [production managers] into our decision-making meetings, but they just get bored. They are still in their own little area. I would love it if they would join us more, because then they can to see that they are not an isolated unit, there is a whole supply chain out there.
>
> Sometimes they choose to forget that. When they want to go fast, they don't care who that affects. Even though they do know that they have an affect up and down. [Lee, planner and scheduler, Unit A]

The main focus of production managers remains production of tonnes and high throughput; this focus is reinforced by their performance measures. Since production managers are permanent parties in the negotiation of the production schedule, their interests persistently bias negotiated solutions towards non-Lean practices.

5.2.2.8 Impeding: Shared resistance to stop a machine

Although this resistance to stop a machine has been discussed is related to individuals, this resistance is also contextual. Findings reveal a strong shared resistance towards stopping production. Prior to the implementation of Lean strategy, a widely accepted view in the organisation was that production should never be stopped; the idea was incomprehensible. The following quote demonstrates the novelty of this practice:

> We were introducing something entirely new. You would never stop the line, absolutely never. Not in the history of the Mill, or even [the entire organisation]. And we actually stopped them. [Vincent, project manager, the mill]

Stopping a production machine is still seen as a negative step. This step requires strong justification, not only to appease production managers but also to justify the direct reduction of capacity utilisation. This focus on continuous production is driven by the company's top management. Machines are only stopped when there is a threat of congestion that will stop production completely, or if inventory is about to exceed the budget. However, machines are not stopped if demand for production is low. Production that is not addressing demand is a violation of Lean practices, as it accumulates unnecessary inventory. However, this strong bias against stopping a unit from running strongly impedes the alignment with Lean strategy. Evidence of this bias is summarised in Table 5.10.

Table 5.10: Evidence of a common bias against stopping a machine

Culture and top management focus on continuous production	Whether you like it or not, this president right now, like the president before, is very heavily focused to keeping lines running. That's our [motto]: "don't stop the line". There might be kanbans, and that all makes sense and you do all this training "you should never exceed a kanban", until the first time you try and stop a production unit.… [A kanban] is just a guide. Production definitely [is a priority] [Fred, master

	scheduler, Unit A]
Continuous production to achieve capacity utilisation	To stop the mill, you're just stopping the production of material. Every coil they can process over there, we're making money on. So they're down to 24 hours, 36 hours. It's 36 hours of production stopped, lost. You can't gain that back. [Sam, unit scheduler, Unit A]
Production despite low demand	Sometimes your demand is a bit low and they still want you to keep a unit running, just aim for the upper and make a little bit more than you need to. [Lee, planner and scheduler, Unit A]

5.2.3 Task-related factors

Some of the factors supporting Lean strategy are driven by factual, task-related data, as well as driven by economic imperatives and production requirements. These factors include avoiding double-handling of products, a preference for orders over forecasts, and a preference for low inventory levels. Task-related factors found to impede the adoption of Lean scheduling practices are the need for high utilisation, the use of inventory as a means of delivery, and the use of inventory as buffer against uncertainty. Evidence of these factors is presented next.

5.2.3.1 Supporting: Awareness of the risks of double-handling

Pre-production, i.e., production of product prior to its delivery date goes against Lean practices. In addition, according to Lean strategy, unnecessary movement is a form of waste that has to be minimised. When product is processed prior to its due delivery date, it has to be moved into storage, and then moved again to delivery.

In this organisation, every movement carries the risk of damaging the product, by physical dents and scratches. When schedulers are aware of these risks to product

quality, they prefer to avoid unnecessary movement. This preference was evident in interviews as well as informal conversations; for example: "I don't want to take it out of the [machine] because that is double-handling" [Vera, unit scheduler, Unit B]. This awareness of the negative impacts of unnecessary movement therefore supports Lean practices.

5.2.3.2 Supporting: Preference of orders over forecast

Lean strategy in its classic form does not require forecasting; however, forecasting is a reality in many businesses, and this reality has been accepted into Lean practices. Forecast orders take lower priority in comparison to existing orders in Lean strategy. Preferring forecasts over existing orders can result in excessive inventory, and if forecast orders were to be prioritised (for example, in order to achieve large batch sizes), this would lead to high inventory, counter to Lean principles. Thus, preferring existing orders and aiming to deliver them on time reduces potential inventory levels, and aligns with Lean practices. An example of preferring an actual order over a forecast order is demonstrated in the next quote.

Yesterday we were running so well, flowing along beautiful, [and suddenly our] crane dies. Total chaos, nothing goes to that bay and that's our most widely used bay, and hardly any room in the other bays. So now I've got to send material out. [I checked to] see what was prioritised: priority for customers. [I put] customer coils in the dispatching fields, and [put away] anything that was [based on forecast]. [Ronald, shift controller, Unit A]

This quote demonstrates a situation when delivery is constrained. The controller in this case prioritised material that needed to be sent to customers over material that needed to be moved and stored as inventory. This prioritisation of actual orders over inventory-building is consistent with actions of schedulers and planners. These actions

support the reduction of inventory, and thus support Lean practices. This practice is closely related to the focus and awareness of customer needs, addressed in Section 5.2.2.2.

5.2.3.3 Supporting: Preference for low inventory levels

One of the major aspects of Lean strategy is maintaining low inventory. Schedulers' preference for low inventory levels thus supports this aspect of Lean strategy. Two factors were found to support schedulers' preference for low inventory levels: budgetary reasons, and practical reasons of space limitations. These factors are presented in Table 5.11.

Table 5.11: Reasons for preferring low inventory

Budget supporting low inventory	For example, we have to stop number 3 paint line because we are making too much inventory and it will blow the budget I think that [several weeks] is a hell of a long time to carry extra inventory, in preparation for a planned downtime. [Lee, planner and scheduler, Unit A]
Space limitations supporting low inventory	There is no point cutting [the slab] until you are going to schedule [it] because don't forget slabs take up more room than skilts because you have lots of little ones. Instead of one big stack of skilts, you have got another four instead of one and they have got to find a place for it. [Vera, unit scheduler, Unit B] Instead of using up all our room and then have nowhere to put it, I can conserve some room for that material to come [Ronald, shift controller, Unit A]

5.2.3.4 Impeding: Need for high utilisation

There is an accepted view across units and functions that utilisation has to be maximised. Capacity utilisation under Lean strategy is high, and Lean strategy does not

suggest sacrificing it. However, utilisation in Lean strategy is achieved indirectly, by scheduling small batches and short runs.

The pressures to achieve high capacity utilisation lead schedulers to avoid stopping production lines. Changeovers are also not viewed favourably, as each changeover is seen to carry the risk of machine breakdown. Table 5.12 presents evidence.

Table 5.12: Evidence of biases and pressures to maintain high utilisation

High utilisation required	The policy at [Unit A] is to load every single unit to 100%, so full 100% utilisation. Every year we go through a budget and so are all my budgets achieved in terms of utilisation, unit throughput, how many tonnes go through each line, despatches There is an expectation that we will always keep the lines running. [Lee, planner and scheduler, Unit A]
Stopping a line as utilisation loss	Their [production managers'] main target is utilisation: "how many tonnes can I get through my unit". If I was to make a decision which stopped one of the units, there would be serious questions asked by my boss and the bosses of the units, there would be serious questions asked. [Lee, planner and scheduler, Unit A]
Reluctance to changeover	The less you fiddle with the machine the more reliable it will be - there is that concept, you don't touch it. Every unit would love to just run the same thick size and colour non stop [Lee, planner and scheduler, Unit A]

The pressure to maintain high capacity utilisation is present in the schedulers' minds when they make scheduling decisions, and directs their efforts and attention to solutions that address this pressure. This focus is different to the focus required for Lean practices such as levelled scheduling and small batches. Lean practices require more

changeovers, and thus the pressure to maintain high utilisation does not support Lean strategy.

5.2.3.5 Impeding: Inventory levels perceived as means of delivery

Schedulers believe the time required to satisfy an order is far longer than the time required to process a product. This difference between processing time ("value-add time") and time required for production ("production lead time") is far smaller when Lean principles are followed. However, in this organisation, this difference is enormous: production lead time is about seven weeks, whereas the value-add time is less than two days.

The problem with a lengthy production lead time is that it is also far longer than the time the customer is willing to wait for their order to arrive – "order lead time". When the order lead time is exceeded by the production lead time, orders must be satisfied using pre-made inventory. Thus, inventory levels are expected to be kept high, contrary to the Lean practice of reduction of inventory. Table 5.13 presents quotes demonstrating these points.

Table 5.13: Evidence of erroneous belief in inventory as the means to delivery performance

Production lead time versus value-add time	The actual processing time would be hours. …[our lead time] is really just the queue length. We order [feed from our upstream unit, and it takes] two weeks to get the coil to the beginning of our unit. Then I give it three weeks to get through [our unit], whereas the physical processing time is very small. If you could somehow juggle it, you could get it within one day. But we have to have batches and queues, to get [production] unit efficiency [Lee, planner and scheduler, Unit A]
Inventory as a means to address demand	Because 70% of our product is [delivered from] stock, if you haven't got enough [stock] there, you are in trouble. You might not be able to supply the customer.
	The assumption is that if we have the right amount

	of stock there, we will get good delivery performance. [Lee, planner and scheduler, Unit A]

5.2.3.6 Impeding: Inventory levels as buffer against uncertainty

Inventory is seen as a buffer against uncertain events, and schedulers perceive their environment as disruptive and saturated with uncertainties. The risk-averse nature of this company, the perception of a problematic and uncertain production environment, and unpredictability in demand, together support higher levels of inventory for the sake of insurance. This goes against the Lean practice of maintaining low inventory. Table 5.14 summarises evidence of the use of inventory as a buffer.

Table 5.14: Evidence of the use of inventory as a buffer

Uncertain production environment	Our unit performance is poor, very, very variable. We are not world class, it is very low and so a lot of the safety stock [has] to account for unit performance. [Lee, planner and scheduler, Unit A]
Unpredictable demand	At the moment our demand changes very dramatically. It is quite seasonal and we are not very good at picking the correct flows of the demand. We are constantly changing [production plans] within a very short horizon. It is not uncommon to get changes for the forecast for the month that you are in. [Lee, planner and scheduler, Unit A]
Inventory as a means of satisfying demand	This plan [means] that I am going to be short and not have enough stock through that period of time. So there [I may not] achieve unit utilisation and delivery performance. This is not good. The assumption is that if we have the right amount of stock there, we will get good delivery performance. [Lee, planner and scheduler, Unit A]

5.2.4 Summary

This section provided evidence of various factors that support or impede Lean scheduling practices in this organisation. Individual factors identified in this study highlight the role of schedulers' emotional aspects in scheduling decisions. The contextual factors in this study demonstrate how the priorities of their unit and organisation, such as collaboration versus localised performance, prioritisation of customers, and resistance to machine stopping, influence their scheduling decisions. Finally, task-related factors demonstrated how process requirements and task objectives can support or impede the adoption of Lean scheduling practices.

Many of the factors discussed in this section closely relate to assumptions shared by organisational members, including the schedulers. These assumptions are presented in the next section.

5.3 Shared assumptions

This section presents the concepts addressing the third research sub-question: "*What shared organisational assumptions and practices support or impede the adoption of Lean scheduling practices in the steel industry?*" Many of the factors identified in Section 5.2 are related to assumptions shared by the schedulers and other organisational members. These assumptions were sometimes stated directly by participants. At other times, the assumptions emerged from an analysis of the factors identified in Section 5.2. This section uncovers these assumptions (summarised in Table 5.15 below), based on direct statements and supporting evidence from the analysis of interviews and organisational documents.

5.3.1 Assumption 1: The source of business success

A shared assumption regarding the source of business success is evident when the objectives (and resulting priorities) are examined. Schedulers referred to the change in perception of the importance of timely delivery. Schedulers indicated that at present, the focus on high utilisation and production quantities is decreased compared to the focus on timely production, and that even production managers (whose performance is not measured based on timely delivery) accept that their own objectives (high throughput and production levels) may need to be sacrificed in order to achieve it (Section 5.2.2.2).

Table 5.15: Shared assumptions supporting or impeding Lean strategy			
Factors	**Assumption**	**Supporting**	**Impeding**
▪ Customer/ production focus ▪ High utilisation need ▪ Shared resistance to stopping a machine	The source of business success	The source of business success is addressing customer demand on time	The source of business success is production of quality product with low costs
▪ Collaborative focus ▪ Localised performance measures ▪ Shared resistance to stopping a machine ▪ Overselling	How to address customer needs	Collaboration between functions is necessary to best answer customer needs	Optimising each function's core activity best answers customer needs
▪ Shared resistance to stopping a machine ▪ Quarterly inventory measurement ▪ Inventory for delivery ▪ Inventory as a buffer	The role of the kanban	Kanbans support the reduction of WIP and help achieve perfection	Kanbans are an indication of inventory levels and inventory costs
▪ High utilisation need ▪ Shared resistance to stopping a machine ▪ Preventive maintenance ▪ Inventory as a buffer	How to achieve high production volume	High production volume is achieved by perfecting core activities and changeovers	High production volume is achieved by high utilisation and large batches
▪ Inventory as a buffer ▪ Inventory for delivery	Length of production lead time	Production lead time is not far greater than order lead time	Production lead time is far greater than order lead time

In contrast to this prioritisation of timely delivery, evidence from the implementation case suggests that the organisation used to make production quantities a priority, which achieve scale economies and reduce production costs. This prioritisation of high production quantities is also evident in current pressures to maintain high utilisation (Section 5.2.2.8), and in the shared resistance to stopping a machine (Section 5.2.3.4). The prioritisation of one objective over another indicates that this objective is viewed as important to the overall goal referred to by many – business success.

Once timely delivery is acknowledged as an importance aspect of business success, production of smaller batches (which is at the core of Lean strategy) is more acceptable. In turn, this acceptance enables schedulers to prescribe small batches for production, without being seen as risking business success.

5.3.2 Assumption 2: How to address customer needs

Even if customer needs (including timely delivery) are viewed as critical to business success and important to address, the question of how to address them remains open. Two different assumptions regarding this question are inferred in this case study: one assumes customer needs can best be addressed by communication between all functions and a coordination of their efforts. The other assumes that each organisational function should perfect its own operation.

The first assumption is evident in the importance placed on collaboration and interpersonal skills that enable such collaboration in Unit A. The scheduler in this unit explains that the scheduling team needs relationships in order to perform their role well, and the planner, who is involved in hiring, explains that inter-personal skills are superior

in her view to task-related skills in their unit (Section 5.2.2.1). The emphasis that schedulers in this unit place on relationships is also evident when the schedulers' role as a negotiator and influencer is presented (Section 5.1.2). Evidence indicates that the schedulers dedicate time and effort in order to build and maintain these relationships with other organisational functions: production, maintenance, and sales. Obviously collaborative relationships cannot be established unilaterally, and the fact that these relationships are established indicates that the other parties reciprocate and support them. This collaborative focus indicates that schedulers and other unit members view them as valuable to the successful performance of their role.

In contrast, a different assumption is evident when examining localised performance measures (Section 5.2.2.7), which support overproduction (Section 5.2.2.8) and overselling (Section 5.2.2.6). These performance measures, and the localised focus that aligns with them, indicate that sales and production view their core activities as the source of business success. Production views their ability to produce *efficiently* (and not necessarily *effectively*) as critical for success, and sales view their ability to sell large quantities as important. When these functions assume that their core activities are the source of success, it is difficult to coordinate these activities, as required by Lean strategy.

When collaboration is accepted as a critical way to achieve business success, the different functions are more accepting of other functions' input, and are more willing to use that input to guide their own operations. This adjustment is critical for the different functions to work in concert, as required by Lean strategy. This study demonstrates that

this shared assumption influences how difficult (or easy) it is for schedulers to align with Lean practices.

5.3.3 Assumption 3: The role of the kanban

Kanban is a simple mechanism designed to restrict product levels, so that production is paced along the supply chain. This mechanism poses an upper level for intermediate product (WIP) between two production units. When this limit is reached, production at the supplying unit is stopped, until the customer unit consumes the WIP and the kanban is "emptied". The kanban mechanism affects the degree to which the operation is aligned with Lean strategy.

In this case, one assumption predominated: that the kanban is simply a guide, and should not be strictly adhered to. This assumption is evident when the scheduler explains how kanban adherence is secondary to production continuum (Section 5.2.2.8). In addition, the fact that limits of inventory levels are only considered once a quarter (Section 5.2.2.5) indicates that these limits are not viewed as critical to performance or business success. This is further reinforced when the schedulers view high inventory levels as necessary for the achievement of timely delivery (Section 5.2.3.6), and as a buffer against uncertainty (Section 5.2.3.6). This view makes kanbans seem obstructive to business success and performance.

However, the implementation case demonstrates how critical kanban adherence for the sustainability of Lean strategy. This is illustrated in the program director's view of how Lean strategy was gradually rejected in the mill, once the new top manager was appointed:

[The new plant manager was] a very highly regarded production guy. … He allowed kanbans to be broken and didn't follow up. [Inventory levels] went up a bit: he didn't do anything about it. [Cameron, program director, the mill]

This permission to breach kanban levels gradually eroded the successful reduction of lead times, as described by the program's sponsor:

Days of inventory rose from 23 through 57, all the way up to 90. They ended up with three months of inventory. [Ross, program sponsor, the mill]

In order to sustain Lean strategy, kanbans need to be strictly adhered to. This point is further discussed in Section 6.3.3.

5.3.4 Assumption 4: How to achieve high production volume

Lean strategy does not advocate for limiting *total* production volume; however, the way high production volume is achieved in this strategy is different to the traditional, intuitive way. Instead of aiming to produce a large quantity every time (by batching different orders into one large production run), Lean strategy requires small batches in a steady and continuous flow.

The traditional assumption, that a high production volume overall is achieved by many individual instances of high production volume, was suggested by one of the implementation team leaders. This team leader explained that production managers are looking to set yearly production records, and they seek to achieve these records by achieving high production levels each shift:

[Production management's] theory is that the only way we're going to get the yearly [production record] is by getting lots of shift production records. [Ian, team leader, the mill]

This view that only large batches lead to high production volume is further reinforced by present pressures for high utilisation (Section 5.2.3.4), and by present resistance to stopping a machine (Section 5.2.2.8). Both factors favour continuous production and large batches as a way to achieve high production volume. These factors suggest that stopping a running machine, even if for a changeover, is seen as having the potential for reduced production volume.

Further support for this assumption is revealed when the role of inventory is examined. Inventory levels are seen as a way to address uncertainties such as breakdowns and surges in demand (Section 5.2.3.6). The schedulers do not rely on production capabilities to address such uncertainties, instead relying on high levels of inventory, achieved while production was possible. This creates an assumption that while machinery is available and production is possible, large batches should be produced. Large batches therefore compensate for lost machine availability. Equipment breakdowns create a sense of urgency to produce large quantities even if not currently required, as the machinery has to be utilised while it is functioning.

Equipment reliability is one way Lean strategy addresses the view that production must be maximised while possible. When the maintenance schedule is adhered to, and preventive maintenance reliably prevents breakdowns, there is less urgency to produce while possible, and Lean practices can be followed.

5.3.5 Assumption 5: Length of production lead time

Lean strategy aims to achieve a drastic reduction of production lead times. This requires the assumption that such reduction is possible. However, if lengthy lead times are seen as necessary evil, this reduction is difficult to achieve.

Schedulers believe that high inventory levels are necessary in order to address demand, as they see demand lead times as longer than production lead times (Section 5.2.3.5). The schedulers explain that they need to build up inventory levels based on forecasts, in order to prepare for short-term demand. The fact that this lead time is extremely lengthy in comparison with the time required for actual processing does not change this assumption, and is not directly related to batching. In addition, the need to build inventory levels to buffer potential breakdowns (Section 5.2.3.6) indicates that uncertainties are seen as potentially harmful for timely delivery. Schedulers do not believe that in the case of a breakdown or demand surge, production would be able to address demand in time. This is in contrast to the actual production (value-add) time indicated of two hours. Typically orders are requested within a few weeks, and few breakdowns last that long. Therefore, schedulers accept that the realistic lead time is longer than order lead times, and do not seek to reduce this gap.

5.3.6 Summary

This section revealed five assumptions that are shared by organisational members. The assumptions were identified based on explanations provided by participants for practices that support (or mostly, impede) the adoption of Lean strategy, and were further supported by evidence of practices related to these assumptions. The assumptions identified are:

(1) **The source of business success** can be assumed to stem from addressing customer demand on time (supporting Lean strategy), and from keeping product costs low (impeding Lean strategy). This assumption is related to the focus of the unit: production focus (impeding Lean strategy) versus customer

focus (supporting Lean strategy), the need for high utilisation, and a resistance to stopping a machine (impeding Lean strategy).

(2) **Addressing customer needs** can be assumed to be done through collaboration (supporting Lean strategy) or local optimisation (impeding Lean strategy). This assumption is related to the degree of the units' collaborative focus, localised performance measures, overselling, and resistance to stopping a machine.

(3) **The role of the kanban** can be seen as either fundamental (supporting Lean strategy) or indicative (impeding Lean strategy). This assumption is related to the resistance to stopping a machine, quarterly measures of inventory, and the use of inventory as means of delivery and as a buffer against uncertainty.

(4) **Achieving high production volume** can be seen as either through a continuous operation of small batches, with perfected activities and changeover (supporting Lean strategy) or through high utilisation and large batches (impeding Lean strategy). This assumption is related to the need for high utilisation, resistance to stopping a machine, preventative maintenance, and the use of inventory as a buffer.

(5) **The length of production lead time** can be seen as either close to order lead time (supporting Lean strategy) or as far greater than order lead time (impeding Lean strategy). This assumption is related to the use of inventory as a buffer against uncertainty, and as a means of delivery.

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Chapter 6 Discussion

Findings presented in the previous chapter addressed the three research questions by identifying the roles schedulers play in the organisation studied, by identifying task, individual, and contextual factors that influence scheduling decisions, and by identifying assumptions shared by organisational members that are relevant to scheduling decisions, along with the factors that influence these decisions. This chapter discusses these findings and compares them to previous findings described in the literature.

Section 6.1 addresses schedulers' roles and compares these findings to current literature. Section 6.2 discusses individual factors found to influence scheduling decisions in the context of current behavioural decision-making literature. Finally, Section 6.3 discusses underlying assumptions found in this case to support or impede the adoption of Lean scheduling practices, and discusses them in the context of previous studies relevant to Lean strategy.

6.1 Schedulers and the adoption of Lean strategy

This section addresses the first research sub-question: *What role do schedulers in the steel industry play in the enactment of Lean strategy, and how does it compare with schedulers' previously described roles?*

Most of the roles of schedulers identified in this case were consistent with previous findings. Previous studies have described schedulers playing the role of information nodes, influencers and negotiators, and problem anticipators and solvers (Jackson, Wilson & MacCarthy 2004; Berglund & Guinery 2008). However, the centrality of schedulers to the successful adoption of a strategy has not previously been made explicit. Two major themes underlie the centrality of schedulers to the enactment

of Lean strategy: (1) the scheduler's role as a negotiator and facilitator, and (2) the importance of the scheduler's discretion and prioritisation in scheduling decisions.

6.1.1 The scheduler as negotiator and facilitator

Previous literature identifies the importance of interpersonal relationships to the operation of schedulers (Jackson, Wilson & MacCarthy 2004; Berglund & Karltun 2007). Schedulers, as described in previous studies, often lack formal control over the other functions they work with, and thus use relationships as a source of influence. The importance of interpersonal skills in this study is evident, for example in hiring practices in Unit A, where interpersonal skills are preferred over task-related skills. It is also evident in schedulers' expenditure of time and effort to build and maintain a rapport with the various operators. These findings are consistent with the literature.

While previous studies of Lean strategy emphasise the importance of cohesive relationships among team members (e.g., McLachlin 1997; Fraser, Harris & Luong 2007), this study emphasises the importance of interpersonal skills of and relationships maintained by *schedulers*. Cross-functional collaboration is achieved in discrete industries by restructuring the organisation into product-based cells, rather than functional departments. However, this study suggests that schedulers are particularly critical to this collaboration in the steel industry, more so than in discrete industries, since cellular manufacturing and work teams cannot be implemented in the steel industry (Belvedere & Grando 2005; Shah, N. 2005; Shah, R. & Ward 2007). The collaboration between the different functions has to be facilitated by a central position, which holds an overview and an understanding of the entire operation.

Schedulers are key to the coordination and collaboration between different organisational functions (production, sales, and logistics) that Lean strategy requires. Schedulers facilitate this collaboration by using their interpersonal skills. They make the various organisational functions (e.g., sales, production, and logistics) aware of each other's needs and constraints. In addition, schedulers influence the various functions by explaining to them the impact of their actions on overall business success. For example, schedulers explain to production managers that if they continue to overproduce, they will exceed the budget. Therefore, schedulers draw on their interpersonal skills to establish relationships and facilitate coordination across functions, as required in Lean strategy.

6.1.2 Schedulers' discretion and prioritisation

Schedulers regularly use their discretion to prioritise different needs. Previous studies acknowledge that schedulers determine the priorities of objectives and make decisions regarding trade-offs (Cegarra 2008). This prioritisation is critical to the enactment of Lean strategy, as it determines whether level scheduling is achieved, as required by Lean strategy (Naylor, Naim & Berry 1999). This prioritisation depends solely on schedulers' discretion. Under Lean strategy, schedulers are required to prefer small batches and low inventory levels. When they do not maintain this prioritisation, Lean strategy is not sustained: inventory levels rise and lead times extend.

These priorities contradict traditional priorities in the steel industry, as demonstrated in this study, and as generally found in process industries (Fransoo & Rutten 1994). The traditional preference for large batches and high inventory levels is reinforced by assumptions shared across the organisation, as further discussed in Section 6.3. However, this study emphasises the critical role of schedulers in the steel industry.

Their trade-offs between batch sizes and lead times are at the centre of Lean strategy, and must align with it if it is to be successfully enacted.

Findings in this study also have methodological implications for research on schedulers. Schedulers display their priorities not only by trading-off batch sizes and lead times, but also by drawing on various alternatives to achieve their targets (Section 5.1.3). To prioritise short lead times, schedulers draw on other production facilities to address production demand. Because they prioritise production quantities over customer demand, schedulers use export clients as a relief valve for excess inventory. To lower the priority given to production quantities, schedulers may recommend stopping production lines that overproduce.

The fact that schedulers can often prioritise and make decisions without either affecting or being affected by the production schedule has important methodological implications for studying scheduling decisions. Methodologies that assume scheduling decisions can only be reflected in changes in the schedule (see, for example, Fransoo and Wiers, 2006) need to account for courses of action available to the schedulers that are not reflected in the schedule. Otherwise, schedulers' actions that are not reflected in the schedule may not be accounted for, and thus compromise the study's validity.

6.2 Individual factors influencing schedulers adoption of Lean strategy

Section 6.1 highlighted the influence schedulers have on the adoption of Lean strategy. Scheduling practices are central to a successful and sustainable enactment of Lean strategy: understanding the factors influencing individuals responsible for performing these practices can clarify the difficulties involved in such enactment. This is addressed by the second research sub-question: *What factors support or impede the enactment of Lean scheduling practices in the steel industry, and how do they influence scheduling decisions?* These various factors were divided into three categories: individual, task, and contextual. Individual interpersonal skills and the ability to manage their emotions were found to support schedulers' enactment of Lean practices. Individual attitudes and anticipated emotion were found to impede the enactment of Lean practices.

6.2.1 Individual skills enabling Lean practices

This study shows that schedulers' ability to manage their own emotions can support the enactment of Lean strategy. Lean scheduling practices invoke negative reactions from other organisational parties, mainly production managers: these reactions pressure schedulers to deviate from Lean scheduling practices (Section 5.1.2 and Section 5.2.1.1). In order to consistently align with Lean strategy, schedulers must be able to operate despite this pressure. This research shows that schedulers are able to manage their own emotions and overcome their influence in order to make decisions they find beneficial for the business. This ability to manage emotions can therefore support the enactment of Lean strategy.

In contrast, two main individual factors were found to impede the enactment of Lean practices. One is schedulers' *anticipated emotions*, which were found to impede the enactment of stopping a production line and reduction of inventory. The other is the schedulers' *attitudes*, which led to the rejection of small batches and low inventory levels.

6.2.2 Anticipated emotions impeding Lean practices

Both positive and negative anticipated emotions were found to reinforce traditional scheduling practices. Expectations of positive emotions as a result of achieving large production volume and production records supported overproduction and large batches. Expectation of negative emotions, such as regret and fear, impeded decisions required for the enactment of Lean strategy, such as stopping production, kanban adherence, small batches, changeovers, and low inventory levels, as discussed in Section 5.2.1.2. Negative emotions were expected due to pressures to meet production targets, and due to fear of breakdowns that could prevent achieving these targets. Positive emotions were expected due to a cultural esteem for production records. Expectations of emotions, both positive and negative, led schedulers to favour status-quo decisions that aligned with traditional practices, over Lean practices.

This finding suggests that scheduling decisions, although based on factual considerations, are influenced by anticipated emotions, similar to choices by gamblers, consumer decisions, and interpersonal decisions (Zeelenberg 1999; Connolly & Zeelenberg 2002; Bazerman 2006). This finding also supports the suggestion of Baumeister et al. that *all* expected emotions lead to "safe" choices, including positive

expected emotions (2007, pp. 192-194). This has the effect of rendering people who consider future emotional consequences risk-averse and conservative.

6.2.3 Intuitive evaluation of Lean practices – attitudes

This study provides indicative evidence that schedulers who operated under the traditional strategy developed negative attitudes towards Lean practices over time. Strong pressures to achieve high production targets, maintain high capacity utilisation, avoid machine downtime, and avoid stock outage drove schedulers to develop a preference for schedules that do not follow the rules of Lean strategy. Instead, schedulers developed a preference for high inventory levels that ensured against breakdowns and demand surges, large batches, and a minimal number of changeovers.

These attitudes are plausible, considering the counter-intuitive nature of Lean strategy. This counter-intuitive nature can be attributed to the *saliency* of feedback. Saliency refers to the strength of the tie between the decision and its consequences, and depends on the immediacy and intensity of feedback, among other factors. When the consequences occur much later than the decision, feedback saliency is degraded (Croson & Donohue 2006). In Lean strategy, these consequences specifically occur later than decisions concerning batch sizes and inventory levels. However, when a machine breaks down, or inventory runs out, the consequences are immediate and, in this case, carry negative emotions. In contrast, when traditional practices are followed, the successful production of large quantities is immediately visible and carries positive emotional consequences. This asymmetry between the consequences of the two strategies biases scheduling decisions towards traditional practices, rather than Lean practices.

Although scheduling decisions concerning batch sizes and inventory levels are traditionally treated as computational, combinatorial, and rational problems (Baker & Scudder 1990; Baker & Trietsch 2009), this study demonstrates that schedulers draw on their intuition to make them. This intuition is developed through experience, and provides schedulers with a sense of "right" and "wrong" when it comes to different practices (Slovic et al. 2007). Lean strategy requires practices that counter this intuitive sense, as shown in Section 5.2.1.3, and are therefore difficult to implement in the steel industry. Because schedulers' intuition has been their main strength, it is difficult to expect them to abandon it for the sake of a new set of rules, even if these rules have been logically and practically proven superior.

Schedulers' attitudes towards Lean practices are inferred from the immediate and evaluative nature of their response to these practices. Attitudes are extensively recognised for having an evaluative role towards objects (Fishbein & Ajzen 1975; Slovic, Fischhoff & Lichtenstein 1977; Ajzen 1991). In this case, the object is Lean practices, and a negative attitude towards them develops through lengthy experience. This lengthy experience is typical of schedulers, as shown in previous studies (e.g., MacCarthy & Wilson 2001). As in the previous studies, the schedulers in this study are long-term members of the organisation. This lengthy experience provides a long time for schedulers to develop an attitude.

These attitudes were addressed by the implementation team, who explained how Lean strategy works, and conducted a participative game that demonstrated the value of Lean practices. However, negative attitudes towards Lean practices were evidently not changed. This is consistent with previous findings that showed attitudes formed by

direct behavioural experiences have a stronger influence than attitudes formed through indirect experience (Fazio et al. 1982). Indeed, attitude acquired through schedulers' experience prevailed over attitudes prescribed by the adoption of a new strategy.

Although Lean strategy does not advocate reducing capacity utilisation, and even emphasises the eventual increase in capacity utilisation achieved by supply-chain synchronisation production pacing, it leads to an initial and temporary capacity reduction. In discrete industries, this temporary reduction is addressed by generating excess capacity (Ohno 1988), which absorbs utilisation losses. However, process industries typically cannot generate excess capacity, as capacity is constrained by physical machine capabilities (Crama, Pochet & Wera 2001; Harrison 2005). Therefore, a temporary loss of capacity utilisation is expected at the first stages of Lean strategy implementation. This loss of capacity utilisation is regarded by schedulers as a negative consequence of Lean strategy.

Lean strategy was rejected by schedulers in the organisation studied here as it led to a reduction in performance measures in the short term. These performance measures were related to the *outcome* of their decisions, and not to the *process*. In general, process-related feedback is better than outcome-related feedback when complex mechanisms operate (Croson & Donohue 2006). The effectiveness of feedback is critical to the success of Lean strategy, due to its complex and counter-intuitive mechanisms. This study therefore suggests that performance measures may need to be redesigned to align with the *process* of Lean practices rather than the outcome, thus reducing the dominance of production targets and drawing schedulers' attention to levelled scheduling and small batches.

6.2.4 Summary

Two individual factors were found to impede the adoption of Lean scheduling practices in the steel industry: negative attitudes towards Lean practices, which are learned over time and lead to the rejection small batches, low inventory levels, and stopping production; and expected emotions, which leads schedulers to favour traditional scheduling practices that are status quo and seen as "safe". These factors are relevant to scheduling decisions due to schedulers' reliance on intuitive decision-making.

6.3 Shared assumptions related to task and contextual factors

The previous section discussed the influences of individual factors on scheduling decisions, and how they affect the enactment of Lean strategy. In addition to these individual factors, this study also identified task-related and contextual factors that are relevant to schedulers' adoption of Lean practices. A further analysis of these task and contextual factors revealed assumptions, shared across the organisation, that influence schedulers' adoption of these practices. Schedulers' decisions are strongly interrelated with the operation and performance of other functions, such as production, sales, logistics, and higher management. Therefore, schedulers must take into account the underlying assumptions that shape the perceptions of others.

Decision-making literature does not always make a clear distinction between task-related and context-related variables, since decision context often determines the decision task (Payne, Bettman & Johnson 1993). Indeed, the context in which scheduling decisions are performed in this study determines the scheduling task. Contextual factors influence schedulers' interpretation and perception of constraints, priorities, and objectives. Therefore, contextual and task-related factors are discussed simultaneously with the assumptions shared by organisational members, which influence their adoption of Lean strategy. Each assumption is inferred from several factors identified to support (or impede) Lean scheduling practices. In addition, each assumption relates to a different aspect of Lean strategy, described in Section 1.1. Table 6.1 summarises these assumption and the Lean principle they influence.

Table 6.1: Shared assumptions and corresponding Lean principles	
Assumption	**Lean principle**
• The source of business success	• Value
• How to address customer needs	• Value
• The role of the kanban	• Paced production • Continuous improvement
• How to achieve high production volume	• Paced production
• Length of production lead time	• Continuous improvement

6.3.1 The source of business success

The source of business success relates to the perception of *value*. When the source of business success corresponds with a customer-centric view and involves timely delivery of customer orders, it is easier to align scheduling decisions with Lean practices than when low-cost products are seen as the source of success. Lean strategy seeks a systematic method to achieve timely delivery, whereas traditional manufacturing seeks low-cost production. Aiming for low-cost production leads to a focus on cost reduction, which causes schedulers (and other organisational members) to overweight the immediate and certain costs of small batches and kanban adherence. This preference of certain cost reduction over the generation of intangible value can be attributed to base rate bias (Bar-Hillel 1990), which leads individuals to prefer specific information over general information that may be more relevant.

This preference, in turn, leads to scheduling decisions that do not align with Lean strategy. To support Lean production, timely delivery needs to be acknowledged as a source of value in steel products. This acknowledgement supports scheduling

practices that reduce production lead times, at the expense of local efficiency and cost reduction. Indeed, previous findings indicate that a shared awareness of customer needs supports the adoption of Lean strategy (Nahm, Vonderembse & Koufteros 2004), although this support was not directly linked to scheduling practice. The current study offers insight as per how the understanding of customer needs supports Lean practices. For example, when timely delivery is seen as important, it justifies stopping production, even though production stopping reduces the achievement of localised production targets.

Paradoxically, Lean strategy does not result in increased overall production costs. Although smaller batches are traditionally non-economical in process industries (Crama, Pochet & Wera 2001; Shah, N. 2005), the reduction of batch size required by Lean strategy does not necessarily lead to greater costs, as the increase in localised costs is offset by the increased overall productivity. Previous studies of the adoption of Lean strategy in the steel industry did not report cost increases (Dhandapani, Potter & Naim 2004; Harrison 2005; Abdulmalek & Rajgopal 2007; Storck & Lindberg 2007), and neither was an increase evident in this study. However, this study shows that an assumption that high utilisation reduces costs and supports business success (Section 5.2.3.4) impedes the adoption of Lean strategy.

The awareness of customer needs, in this case, counters the influence of pressures to deviate from Lean practices, such as the need to produce large quantities, maintain high utilisation, and avoid stopping a machine. Since the entire plant is aware of the need to address customer needs on time, the scheduler can more easily advance Lean practices when justifying decisions to other parties and stakeholders. As discussed

in Section 2.5.1, the need to provide justification can make some decision aspects more prominent in the decision-maker's mind (Simonson 1989). Thus, having customer needs as a potential objective makes the justification of Lean practices less difficult than if this awareness was not present among the other stakeholders.

When schedulers give low importance to pressures from production functions, they are more likely to prefer customer needs over production of large quantities. Results show that compared with past years, contemporary schedulers are less focused on accommodating production's requests for high volume (Section 5.2.2.4). When Lean strategy was previously implemented in this organisation, the demands production managers placed on quantities and tonnes were more widely accepted by the scheduling team, whereas at present, there is greater awareness within production units of addressing customer needs, rather than achieving large quantities.

6.3.2 How to address customer demand

Closely related to the previous assumption on the source of *value* is the assumption on how it is achieved. While the traditional approach emphasises the optimisation of core activities (such as sales and production), Lean strategy emphasises the coordination and synchronisation of these functions through collaboration.

Although collaboration is commonly mentioned as an important aspect of cellular manufacturing (McLachlin 1997; Fraser, Harris & Luong 2007), or as an aspect of product design (Womack & Jones 2003), this study shows that even though cellular manufacturing is inapplicable, and even when product design does not take place, a collaborative focus is necessary in the steel industry as well. A collaborative focus enables schedulers to influence the stakeholders involved in developing and enacting

the schedule, and enables schedulers to balance cross-functional needs. Schedulers in process industries therefore facilitate the type of collaboration achieved in cells in discrete manufacturing.

Some performance measures do not encourage a collaborative focus, but rather localised optimisation of core activities. Such performance measures (described in Section 5.2.2.7) legitimise the focus of production units and sales representatives on their core activities. Localised performance measures reduce the focus on collaborative efforts with other functions. For example, overselling is strongly criticised by proponents of Lean strategy (Womack & Jones 2003, p. 56), and referred to as "one of the greatest evils of traditional selling and order-taking systems". The authors explain that overselling is an indication of poor "knowledge of or concern about the capabilities of the production system" by sales workforce, and its damaging consequences are late deliveries and bad will from customers.

However, when the parties understand the importance of synchronising their efforts, they are more aware of their own impact on the overall business and supply chain. This awareness increases the acceptability of Lean practices, such as kanban adherence, that reduce localised achievements.

6.3.3 The role of kanbans

Kanban adherence is strongly emphasised in literature as critical to the sustainability of Lean strategy (Ohno 1988; Monden 1994; Hopp & Spearman 2004). Kanbans ensure paced production along the entire supply chain, and do not permit localised production peaks that do not take into account other production units. Kanbans also expose imperfections and problems in the production process, and thus

facilitate continuous improvement (Billesbach 1994). When this role of kanbans is understood and accepted, adherence to kanbans facilitates a sense of urgency to resolve the problem that stopped production.

In contrast, this study shows that implementing kanbans is insufficient for the sustainability and enactment of Lean strategy. In addition to their implementation, the critical role of kanbans in sustaining continuous production needs to be understood. Otherwise, if kanbans are seen as merely a guideline that indicates the state of inventory compared with planned budget (Section 5.2.2.8), and if the kanbans are not strictly adhered to, they are not effective in supporting Lean strategy. Kanbans in these circumstances do not maintain paced production, and do not help detect problems that prevent it.

Two main factors impede kanban adherence. First, kanbans are only measured quarterly, and not more frequently (such as daily). Therefore, the schedulers are not forced to consistently adhere to inventory levels dictated by kanbans (Section 5.2.2.5). In addition, a shared resistance to stopping machines overrides the importance of the signals given by kanbans. This resistance to stopping machines is further reinforced by the need for high utilisation, which also overrides the need to address problems exposed by a full kanban (Sections 5.2.2.8 and 5.2.3.4). However, when there is a preference for low inventory due to space limitations, kanbans must be adhered to. Indeed, a physical limitation of storage space has been the most effective way to enforce kanban adherence in this organisation (Appendix C, Section A) and can be a method to support the adoption of Lean strategy.

Second, although schedulers' performance measures support kanban adherence, the influence of these performance measures is overpowered by the pressure to maintain high utilisation. Previous studies of schedulers' objectives showed they prioritise due dates over utilisation (Cegarra 2008), but in this case high capacity utilisation receives equivalent importance, even though scheduling decisions initially aim to achieve timely delivery. Schedulers overtly claim that due dates are more important than utilisation levels. However, in practice they aim to achieve full capacity utilisation. High capacity utilisation is maintained despite product levels exceeding kanbans. Thus, the role of the kanban is not assumed to be critical to business success, and this assumption impedes the enactment of Lean strategy.

6.3.4 How to achieve high production volume

Lean strategy claims that high production volume can be maintained when small and standardised batches are constantly produced along the entire supply chain. These small and standardised batches lead to a predictable, stable, and consistent production pace. In other words, with Lean strategy, high production volume is achieved over time.

In contrast, an assumption that high production volume at every run results in high production volume overall impedes the adoption of Lean strategy. This assumption leads to the scheduling of large batches, which result in high inventory levels (Lieberman, Helper & Demeester 1999), and eventually leads to congestion and reduction of overall production volume (Simchi-Levi, Kaminsky & Simchi-Levi 2003).

In this study, the latter assumption was implicitly raised when schedulers explained why they would not stop a machine, or how they need to achieve high

utilisation. There is an underlying assumption that stopping a running machine, even if for a changeover, leads to low production volume (Section 5.2.2.8).

Changeovers also represent a risk to the machine's ability to continue production. Improving the changeover process is central to the success of Lean strategy (Ohno 1988; Womack & Jones 2003; Hopp & Spearman 2004). Proponents of Lean strategy claim that changeovers must be perfected by reducing their duration and ensuring their reliability, so that they do not cause a significant reduction in production capacity. Indeed, reports of successful adoptions of Lean strategy in the steel industry indicate that changeover times were significantly reduced and their reliability was significantly improved, in order to support Lean practices of small batches (Dhandapani, Potter & Naim 2004; Harrison 2005; Abdulmalek & Rajgopal 2007; Storck & Lindberg 2007). In this case, however, the assumption that high capacity utilisation is reached by large batches indicates that changeovers are still regarded as disruptive and harmful to production volume. This assumption promotes large batches, which lead to high inventory levels, and thus impede the adoption of Lean strategy.

Another factor reinforcing the assumption that high production volume requires large batches is equipment (un)reliability, identified in Section 5.2.3.6 as a source of uncertainty. When the equipment is seen as unreliable, schedulers expect breakdowns which reduce production capacity. This creates an assumption that while machinery is available and production is possible, large batches should be produced. Large batches therefore compensate for lost machine availability. Equipment breakdowns create a sense of urgency to produce large quantities even if not currently required, as the machinery has to be utilised while it is functioning.

Preventive maintenance, however, promotes predictable production availability. This predictability reduces the urgency to produce when possible and to produce large batches, as the scheduler can be reasonably certain that future demand can be addressed by future production. Lean strategy requires the adjustment of maintenance practices (Spencer & Guide, 1995) so that production predictability is achieved. This case demonstrates how adjusting maintenance practices can support the modification of assumptions required for the success of Lean strategy.

A preference for large batches can also be attributed to the saliency of feedback, discussed in Section 6.2.3. Saliency refers to the strength of the tie between the decision and its consequences. When the consequences occur significantly later than the decision, feedback saliency is degraded (Croson & Donohue 2006). Since in Lean strategy, high production volume is achieved over time, this achievement is not as salient as the immediate achievement of high production volume due to a large batch at a time. When large batches are scheduled, the successful production of large quantities is immediately visible. This asymmetry between the visibility of consequences of the two strategies impedes the adoption of Lean scheduling practices.

Seeking high production volume at every run impedes paced production, which can only be achieved when small standardised batches are produced (Rother & Shook 2003). When scheduling aims for localised high volume, it is impossible to achieve paced production, which is central to the continuous flow of product required by Lean strategy.

6.3.5 Length of production lead time

One of the major aims of Lean strategy is to reduce the time it takes to produce a product (i.e., production lead time) so it is as close as possible to the duration of actions necessary for production (i.e., value-add time) (Rother & Shook 2003; Womack & Jones 2003). In process industries, it is not uncommon to find value-add times that represent a small fraction (less than 5%) of the total production lead time (Shah, N. 2005). This enormous gap leaves ample room for improvement, and indeed, successful adoptions of Lean strategy in the steel industry report dramatic reductions of their production lead times. However, if schedulers (and other organisational members) assume these lead times are set, and cannot be changed, such a reduction is not likely to be achieved, as demonstrated in the case studied here. In this case, inventory is viewed as the only possible way to address customer demand (Section 5.2.3.5). The efforts for improvement then focus on maintaining a high level of inventory, which can satisfy demand on time when orders are accepted, and when unpredictable breakdowns occur. Inventory as means of insurance is not uncommon (e.g., Davis 1993); however, Lean strategy sets against this view of inventory, and aims to minimise the uncertainty that calls for such insurance. The acceptance of high inventory levels contradicts Lean scheduling practices, and thus impedes the adoption of Lean strategy.

6.3.6 Summary

This study reveals five underlying assumptions that are relevant to three main Lean principles. Two assumptions relate to the principle of value: the core of business success and how customer demand is addressed. Two assumptions relate to paced production: the role of the kanban, and how to achieve high production volume.

Finally, two assumptions relate to continuous improvement: kanban adherence and the difference between lead times and value-add times.

These assumptions dictate practical behaviours that can support or impede the successful and sustainable adoption of Lean strategy in the steel industry. This study shows how each assumption relates both to the behaviour necessary to support Lean scheduling practices, and to Lean principles.

6.4 Contributions and implications of this study

The discussion chapter has identified several different contributions which have implications for theory, practice, and methodology. This section highlights these specific contributions and their implications.

6.4.1 Contribution to theory: identifying a new role of schedulers

To date, theory on schedulers has only defined three roles of schedulers: information nodes, influencers and negotiators, and problem anticipators and solvers (Jackson et al., 2004; Berglund & Guinery, 2008). This study identified an additional role. The schedulers in the steel industry play an important role when Lean strategy is implemented, enacted, and sustained. Schedulers decisions are central to production and manufacturing operations in the organisation, and are able to sustain (or as in this case, lead to the failure of) the sustainability of Lean strategy. This role of the scheduler as a strategy executor was not previously described in the literature; however, this study demonstrates that it is critical to the sustainability of Lean strategy in the steel industry.

6.4.2 Contribution to theory and practice: The contextual influence of production on schedulers

Schedulers cannot, and do not, sustain a strategy by themselves. Since schedulers often lack formal authority over the various stakeholders that they schedule for (Berglund & Guinery, 2008), their influence is limited to what can be achieved by bargaining and favours (Jackson et al., 2004). The context in which they schedule therefore strongly influences schedulers' ability to adopt lean scheduling practices.

Therefore, addressing the priorities of the parties that normally negotiate with production schedulers can be critical to the sustainability of Lean strategy. In particular, the priorities and demands of production managers need to be addressed. This finding bares practical implications for adopters and implementers of Lean strategy in process industries.

One of the contextual factors that were found to impede the adoption of Lean strategy was the contextual expectation and motivation to reach high production volume. A success in achieving high production volume is still considered one of the main indicators of the success of a business unit in the steel industry. Even an episodic achievement (such as high production volume in a single shift) is greatly appreciated in this industry. This motivation to outperform other units and other production managers (both past and present) was found very difficult for schedulers to counter. However, it is necessary to abandon this motivation if Lean strategy is to be successfully adopted. Theory on the adoption of Lean practices therefore gains an insight into the central role of schedulers on one hand, and on the other hand, the influence that production units have on these schedulers.

6.4.3 Contribution to theory and practice: Schedulers facilitate cross-functional collaboration

Theory on Lean strategy has strongly advocated for cross-functional collaboration, which has been adopted by many practitioners. However, in the process industry, cross-functional collaboration cannot be achieved by cellular manufacturing. Instead of direct collaboration between the different functions, the collaboration has to be facilitated by a central position, which holds an overview and an understanding of

the entire operation. Schedulers, who have this view and understanding, were found in this study to facilitate the coordination and collaboration between different organisational functions (production, sales, and logistics) that Lean strategy requires. They make the various organisational functions (e.g., sales, production, and logistics) aware of each other's needs and constraints. Schedulers also use rational explanations to influence the various functions, when they explain to them the impact of their actions on overall business success. This finding broadens the existing forms of cross-functional collaboration, and draws attention to the role of schedulers in this capacity.

6.4.4 Contribution to theory and practice: Schedulers' "soft" skills: management of emotions, anticipated emotions, attitudes, and interpersonal skills

The "soft" skills of schedulers were found to have an impact on the sustainability of Lean strategy. Schedulers' inter-personal skills, as well as their ability to manage their own emotions, were found to support Lean strategy. Schedulers' attitudes towards Lean practices, as well as anticipated emotions, were found to impede the sustainability of Lean strategy. These findings highlight the importance of "soft" skills of schedulers for the success of the sustainability of Lean strategy. This has to be considered when Lean strategy is adopted in process industries: do the schedulers of the unit adopting Lean strategy possess these skills?

This finding is also important to advance theory on Lean strategy. Lean strategy emphasises "soft" skills to support collaboration, however this finding details several skills not previously identified in Lean strategy literature (attitudes, management of emotions, and anticipated emotions). This finding also highlights that these skills are particularly important for schedulers.

6.4.5 Contribution to theory and practice: Performance measures for the sustainability of Lean strategy

So far, performance measures have been addressed by Lean literature in terms of the outcome that they should encourage (Fullerton & McWatters 2001). Theory to date suggests that individual performance measures of production workers need to reflect cross-functional training (Karlsson & Åhlström 1995). However, this study shows two new aspects to consider when performance measures are revised for Lean strategy in the process industry: (1) reconsider the performance measures of the schedulers, who are critical to the production process, and (2) revise the performance measures to support the process of adhering to Lean principles (i.e., low inventory and small batches), rather than the outcome of Lean strategy (which is high volume along with responsiveness to customer demand). This principle fits in with previous findings in a different context, showing that feedback for decision processes enables better learning than feedback for decision outcomes (Croson & Donohue 2006). However, this principle has not been previously linked specifically to the adoption of Lean strategy.

6.4.6 Contribution to practice: Priorities of schedulers necessary for the sustainability of Lean strategy

This study emphasises the importance of the daily decisions of schedulers' in the steel industry in sustaining Lean strategy. Schedulers daily trade-off between batch sizes and inventory levels. To sustain Lean strategy, these trade-offs must align with it. Lean strategy can only be sustained if these trade-offs priorities small batches and low inventory levels. This implication for practitioners places a strong emphasis on priorities that must be maintained for the strategy to be successfully adopted.

6.4.7 Contribution to methodology: How to study schedulers' activities

Studies of schedulers have employed a wide range of methodologies (Wiers 1996; Jackson, Wilson & MacCarthy 2004; Berglund & Guinery 2008; Cegarra 2008). Some methodologies have relied on changes in the schedule as a measurement of schedulers' activities (see, for example, Fransoo and Wiers, 2006). This study found that schedulers can make changes with no impact on the production schedule. This means that methodologies used for studying schedulers' activities, that rely on changes in the schedule as a measurement of schedulers' activities need to account for courses of action available to the schedulers that are not reflected in the schedule. Otherwise, schedulers' actions that are not reflected in the schedule may not be accounted for, and thus compromise the study's validity.

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Chapter 7 Limitations

This study has several limitations that make it difficult to generalise its findings. First, it is based a single company. Second, the evidence of schedulers' sources of resistance to Lean strategy was indirect or retrospective. Third, the degree to which the assumptions are shared across organisational members was not tested. These limitations are addressed below.

7.1 Studying a single company

This study is based on a single company, which has its own set of practices, history, shared understandings, and economic conditions. These variables suggest that results may not be transferrable to other steel manufacturers. However, when examining the few reports available on Lean strategy implementation in the steel industry, many of these characteristics appears to be shared (Abdullah & Rajgopal 2003; Harrison 2005; Abdulmalek & Rajgopal 2007; Storck & Lindberg 2007). Other steel manufacturers share practical aspects impeding the adoption of Lean strategy in this organisation: unreliable equipment (Harrison 2005) and monumental in size (Abdullah & Rajgopal 2003), as well as saturated capacity (Abdulmalek & Rajgopal 2007). In addition, other steel manufacturers share many human aspects which include frequent senior management turnover (Harrison 2005), as well as pressures to produce in large quantities (Storck & Lindberg 2007).

Furthermore, researchers can expect that the organisation in this study and other steel manufacturers will have similar cultural elements (Chatman & Jehn 1994). Shared assumptions, which are an element of organisational culture (Schein 2004), are likely to be similar as well. Because the organisational variables influencing the findings in this

study are representative of the steel industry, the results are likely to be transferrable to other steel manufacturers.

7.2 Indirect and retrospective evidence of individual factors

Individual factors influencing schedulers to reject or adopt Lean practices were identified either indirectly or retrospectively. The individual factor that supports schedulers' enactment of a strategy (i.e., interpersonal skills) was identified from direct testimonials of schedulers; however, the organisation studied was not actively implementing Lean strategy. It was found that interpersonal skills assist schedulers' enactment of *a* strategy, and thus it is inferred that these skills would support the enactment of *Lean* strategy. This proposition can be tested in future studies.

The identification of individual factors that impede the enactment of Lean strategy (i.e., attitudes and anticipated emotions) was based on indirect retrospective evidence. As the researcher had no access to schedulers who were active at the time of the implementation, these factors were inferred from retrospective testimonies of individuals involved in the implementation of Lean strategy, and not from direct testimonies of schedulers. In order to address this limitation, a triangulation of these findings through interviews with current schedulers was conducted, and resulted in partial support.

Further confirmation of these findings is possible either by examining the attitudes and anticipated emotions of schedulers during an adoption of Lean strategy in the steel industry, or by surveying schedulers for their attitudes towards and anticipated emotions from following Lean practices.

7.3 How shared are the shared assumption?

Assumptions identified in this study are assumed to be shared amongst organisational members; however, few organisational members from different functions were included as participants in this study. For example, production managers, to whom are attributed most of these assumptions, were not interviewed. However, the broad spectrum of participants in this study (i.e., schedulers, planner, controller, engineers, human-resources managers, and senior managers) confirms that production managers hold these assumptions, and that they dictate many of the fundamental organisational perceptions of the source of business value and success, and the way to achieve high production volume. Further confirmation on the prevalence of these assumptions amongst other organisational members can be attained through quantitative survey research, or further qualitative research such as focus groups, interviews, or qualitative surveys.

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Chapter 8 Conclusion

In search of an understanding of the reasons behind the low uptake of Lean strategy in process industries, this study employed an inductive approach and examined the steel industry. The study focused on the importance of schedulers to the enactment of Lean strategy, and sought to understand the nature of their impact on its adoption. First, the study compared previously described roles of schedulers with their role in the steel industry. Second, based on extant literature on human decision-making, the study developed a framework for various factors influencing schedulers' decisions that support or impede the enactment of Lean strategy. These factors were divided into three categories: individual, task, and context. Third, the study identified the main principles that guide Lean strategy, and suggested that a revision to several underlying assumptions in the organisation would be required.

Using a case-study methodology, the decision-making framework was used to identify various factors involved in a rejection of Lean strategy in a steel-manufacturing organisation, and to explain the way these factors operated, as well as interrelations between them. A thematic analysis of retrospective interviews with key individuals involved in the implementation revealed several factors leading schedulers to reject Lean strategy. These factors were triangulated and supplemented with factors revealed through a thematic analysis of interviews with current schedulers in the organisation.

The individual factors indentified in this research highlight the importance of schedulers' interpersonal skills, as well as schedulers' ability to manage their own emotions. These factors can support the successful enactment of any strategy. In addition, two individual factors that impeded the enactment of Lean scheduling practices

were identified: attitudes and anticipated emotions. The influence of these factors has been previously identified in human decision-making and behaviour literature; however, this study extends their influence to scheduling decisions.

In addition to the individual factors, task-related and contextual factors that influence schedulers' enactment of Lean strategy were identified. A further analysis of these factors revealed a set of assumptions shared amongst organisational members that provide context for – and therefore influence – scheduling decisions. These assumptions are concerned with the source of business success, the way to address customer demand, the role of kanbans, the way to achieve high utilisation, and the length of lead times. Schedulers need an alignment between these assumptions and Lean principles to enact Lean strategy.

Despite the limitations of this study, which drew on a single organisation and relied on retrospective and indirect evidence, it provides valuable insights into the individual factors that impede schedulers in the steel industry from adopting Lean strategy. This study extends on existing operations management literature by highlighting the importance of schedulers to the enactment of Lean strategy, by addressing individual factors that impede this enactment, and by explicating shared assumptions unique to the steel industry that are relevant to this enactment.

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APPENDICES

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Appendix A. Factors influencing scheduling decisions – a thematic analysis

The purpose of this appendix is to demonstrate the process of the first level of analysis, which identified behavioural factors influencing scheduling decisions. The framework for production-scheduling decisions suggests three categories of factors that influence them: *individual*, *task*, and *context*. Factors examined in the *individual* category are attitudes motivation, capabilities, and experience. Factors in the *task* category are information, objectives, and time. Factors in the *context* category are justifiability, the number of alternatives available, and organisational risk aversion.

To identifying the influence of these factors on schedulers' decisions, factors were interpreted in relation to their supporting, impeding, or lack of effect on the adoption of Lean scheduling practices. This analysis served to guide the next two levels of analysis: the identification of task, individual, and contextual factors supporting or impeding Lean strategy adoption (Section 5.2), and shared assumptions relevant to the adoption of Lean strategy (Section 5.3). Evidence for the influence of each factor on scheduling decisions is presented, along with the interpretation of the importance and relevance of the factors to the adoption of Lean strategy.

Section A - Individual

Decision-makers themselves are known to have an impact on the decision. Indeed, different schedulers provide different schedules, as explained in the next quote:

> We each have a different process of getting to [the desired] point. I might save this [batch] for the second cycle and put half it on this cycle. Clay might not, Clay might put it all on [at once]. [Vera, unit scheduler, Unit B]

Three factors were found to influence the difference between schedulers: motivation, capabilities, and experience. Evidence of the influence of each factor is presented next.

(a) Motivation

When composing a schedule, schedulers are motivated by different aspects of their work. Evidence showed schedulers were motivated by achieving business-performance objectives, receiving positive managerial feedback and avoiding negative feedback, and proving their own capabilities and value. There was also a social motivation to maintain a schedule without negative consequences for the next shift. Table A.1 summarises evidence of these motivators.

Table A.1: Schedulers' motivators

Business performance	If you get timely delivery then we are doing well. We are making money [for the business]. [Sam, master scheduler, Unit A] I want to do what is best for the business. [Lee, planner and scheduler, Unit A]
Proving individual capabilities and value	I want to do a good job. [Sam, Unit scheduler, Unit A] There would be questions asked and it would indicate that I was a poor planner if the units were under-utilised. [Lee, planner and scheduler, Unit A]
Achieving positive feedback	The boss would like to see it 100% [delivery performance]; we are lucky if we can get it 95% and still get a bit of a smile out of him. I want to satisfy my boss. [Sam, unit scheduler, Unit A]
Avoiding negative feedback	I don't want to get yelled at, and that means that I will plan to have 100% utilisation of those units. [Lee, planner and scheduler, Unit A]

Social responsibility – helping the next shift	For the next 24 hours I help my partner come in. I do my work for today, but I also do my work for tonight. So if I had to work tonight, it wouldn't be too bad of a shift. I help my mate out as well, and I expect him to do the same for me in the morning. [Ronald, shift controller, Unit A]

Schedulers' motivation to "do the right thing for the business" was instrumental in the understanding of the role of shared assumptions in Lean strategy adoption. Schedulers agreed, across units and roles, about this motivation. Therefore, if schedulers in the past rejected Lean strategy, it suggests their understanding of the source of business success differed to that of Lean strategy.

Schedulers' motivation to achieve positive feedback and avoid negative feedback was central in the understanding of possible influences that impede the adoption of Lean strategy in the steel industry. While achieving Lean goals leads to positive feedback, failing to achieve production targets and utilisation entails risking negative feedback. The asymmetry between the impact of positive and negative expected feedback can explain why avoiding negative feedback prevailed over the attainment of positive feedback, as presented in Section 5.2.1.2.

Finally, the socially motivated aim to assist the next shift can support Lean practices, particularly when preventive maintenance is performed. Preventive maintenance supports a predictable and stable production environment, reducing schedulers' need for high inventory levels, as explained in Section 5.2.3.5.

(b) Capabilities

Three types of capabilities were referred to by schedulers: cognitive, interpersonal, and emotional. However, the importance attributed to these types varied.

Although scheduling is often seen as a complex combinatorial task, drawing on *cognitive* capabilities, several schedulers indicated that apart from extensive knowledge of the specific technical aspects of the plant, scheduling is a simple decision-making process that does not draw heavily on cognitive capabilities. The schedulers illustrated this point by saying "it is not rocket science" (Fred, master scheduler, and Ronald, shift controller, Unit A).

In contrast, interpersonal and emotional capabilities were highlighted by schedulers as critical to a successful performance of their role. The schedulers' interpersonal skills are relevant to their role as influencers and negotiators, when the schedulers' authority does not extend over production or sales functions. In those cases, schedulers draw on interpersonal capabilities to influence other parties to achieve the outcome they are after.

The emotional capabilities were also relevant to scheduling decisions, by influencing (or preventing an influence on) prioritisation. The schedulers describe the risk of making decisions based on negative feedback originating from other functions (such as production), and the need to draw on emotional capabilities to withstand the pressure they exert. Quotes conveying these concepts are summarised in Table A.2.

Table A.2: Capabilities of schedulers

Interpersonal	Our team is successful because we hire people that [have] soft skills, good influencing skills and a fairly good level of interpersonal savvy. I will choose someone that has those skills over someone with knowledge. [Lee, planner and scheduler, Unit A]
	Some people need lots of data and time to digest that, others don't, but it is just dealing with that personality type to get the outcome you want. [Fred, master scheduler, Unit A]

Emotional	You've got to have lots of patience, tons of patience. 'Cause you're dealing with people out on the floor that just wake up in the morning and think, "I think I'll make it hard today for anybody that I talk to". And it's generally what they do [Ronald, shift controller, Unit A]
	Thursday-Friday are the hell of my job, I get abused every time. [Vera, unit scheduler, Unit B]
	When you are a novice, you don't have the confidence in your decisions so you listen to the person yelling the most. [Lee, planner and scheduler, Unit A]

Schedulers' interpersonal and emotional capabilities were so strongly emphasised by participants that these capabilities were preferred to task-related and domain-related knowledge. This contributed to the decision to include these capabilities in the second level of analysis as a factor relevant to the adoption of Lean strategy. Schedulers' cognitive capabilities, however, were not strongly emphasised. The cognitive demands on schedulers were played down. For this reason, schedulers' cognitive abilities were not included in the next level of analysis.

(c) Experience

Schedulers' experience was found to influence their decisions in three ways. First, as expected, experience extends schedulers' domain-specific knowledge, and makes them more familiar with potential solutions (or "avenues") to problems.

Second, experience indirectly facilitates schedulers' influence on other functions, as the schedulers' experience provides them with credibility. This credibility supports schedulers when they need to make decisions that are unfavourable to other functions.

The second quote in Table A.3 provides an example: when the line has to be stopped, the schedulers' credibility is sufficient for production managers to accept it.

Finally, schedulers' experience develops their awareness of the consequences of dealing with negative feedback. The third quote in Table A.3 was discussed in the context of emotional capabilities; however, this quote is also relevant to individual experience. Through experience, schedulers learn not only the practical side of their decisions, and the implications of these decisions for business performance, but also the influence of their own emotions on such decisions. They learn to moderate this influence, in order to achieve business results they strive for.

Table A.3: Contributions of schedulers' experience

Domain-specific knowledge	There's quite a few avenues you can take, but you need to know them. [Ronald, shift controller, Unit A]
Credibility and reputation	I gained really good knowledge and experience, I got a little bit of street credibility by doing that. [Production] people would say: okay, you have worked on shift, so you know the area. They may ask: "have you taken everything into account?" and if I say "Yes, I have, and we have to stop [your line]", they will usually accept that. [Lee, planner and scheduler, Unit A]
Emotional capabilities	When you are a novice, you don't have the confidence in your decisions so you listen to the person yelling the most. [Lee, planner and scheduler, Unit A]

The importance of schedulers' experience was relevant to understanding schedulers' role in this steel-manufacturing organisation. Schedulers are familiar with many possible ways, or avenues, to achieve an outcome. Their reputation enables them to enforce decisions even if these decisions are not favoured by the organisational functions that they affect. Thus, schedulers play an important role in the execution of a

strategy. They can enact a production strategy within a business, and thus their role is central to the adoption of Lean strategy.

The importance of schedulers' experience to their ability to manage their own emotions in order to perform their role supported the conclusion that emotional aspects of scheduling decisions need to be further addressed and understood, in order to provide a complete picture of scheduling decisions that can support (or impede) the adoption of Lean strategy.

Section B - Task

Three task-related factors were found relevant to scheduling decisions: information, objectives, and time. Evidence of these factors is presented next. Quotes demonstrating the concepts presented are summarised in tables at the end of each sub-section.

(a) Information

In some respects, schedulers' information needs are well supported by the organisation's information systems. Schedulers across units indicated they have sufficient information for their decision-making. The information systems in the organisation generally support their information needs, by providing all aspects of real-time information on ordering, current schedule, and inventory position, as well as historical information regarding production, ordering, and delivery.

The organisation's information systems enhance information accessibility by providing visual aids. Graphs display trends, colour schemes indicate inventory levels and their adherence to limits, and visual cues present a virtual state of the plant in terms

of machine status. These visual aids, in the form of graphs, colour schemes and visual cues, increase information availability to the scheduler.

Contrary to these findings, which indicate the organisation's thorough awareness of the need to support decision-makers' information needs, other findings indicate that the schedulers' job cannot be fully automated. Schedulers need to apply human judgement to the information they use. Part of the schedulers' expertise is to interpret and contextualise it. This contextualisation and interpretation is a human function that cannot be automated. Schedulers rely on their experience and their understandings of the interrelationships between various operational aspects for this interpretation. Schedulers apply their judgement to the recommendations of the computerised planning tool, and also elicit priorities from other functions (such as sales) in order to use resources effectively.

In addition to information available through information systems, schedulers receive information via personal contact. This aspect has been presented in Section 5.1.1, under the scheduler's role as an information node. At times, schedulers prefer communicating directly rather than using information systems to elicit information. Examined from a behavioural decision-making perspective, information provided through personal contact is more vividly perceived and more available to the scheduler than information provided through information systems. In addition, these personal interactions build the relationships schedulers require to successfully perform their role. Evidence of these various aspects of information available for schedulers are summarised in Table A.4.

Table A.4: Aspects of information in scheduling	
Information systems visual support	[Our information system] is very graphic, very good data. It does everything from plant flow to product level: at each location in the plant, at our external warehouses, history of each of those, access coil pieces if you want to do it. [Fred, master scheduler, Unit A] It is fantastic, it is a very good visual tool. [It provides] information for decision-making. [Lee, master scheduler, Unit A]
Need for context from human sources	This [computer-generated] plan is saying: "please produce a lot more". We suspect that [in two weeks] we have a maintenance, and the [computerised model] is building that stock now. But I think that is a hell of a long time to carry extra stock. [Lee, planner and scheduler, Unit A] You can work with [customer service], and ask: "I haven't got enough capacity, what's the product you really want me to make?" [Fred, master scheduler, Unit A]
Information exchange as a conduit of relationships	I am a big fan of ringing up and chatting to someone too. As part of this role, you really need that relationship stuff with someone you need to influence. You can't do that via email. [Fred, master scheduler, Unit A]

Evidence on the availability of information indicated that this aspect is not central to the understanding of the rejection of Lean strategy in this organisation. However, evidence indicating that schedulers apply their judgement and influence scheduling decisions beyond the recommendations of computerised models reinforced the conclusion that schedulers are critical to the adoption of Lean strategy. In addition, the time and effort spent by schedulers to nurture their relationships with other members of

the organisation reinforced the understanding of the scheduler as an influencer and negotiator, discussed in Section 5.1.2.

(b) Objectives

Various types of objectives drive schedulers. The targets that are overtly declared as the objectives of a schedule are capacity utilisation, timely delivery (or delivery performance), and adherence to inventory targets. However, in practice, , inventory targets are only measured four times a year, and are therefore treated only as a recommendation during the rest of the time. The other two objectives (production levels and timely delivery) guide scheduling decisions regularly. Although timely delivery guides scheduling decisions, a strong pressure to achieve production targets was evident. These priorities are presented in Table A.5.

Table A.5: Main priorities of schedulers

Production levels priority	Whether you like it or not, this president right now, like the president before, is heavily focused on keeping lines running. That's our [motto]: don't stop the line. There might kanbans, and training says: "you should never exceed a kanban", until the first time you try and stop a production unit. [A kanban] is just a guide. Production definitely [is a priority] [Fred, master scheduler, Unit A]
Timely delivery priority	My major priority is mostly customer getting the coil on time. That's what I try and run by the most, with all the computer systems and everything we have there. … We can't do two things at once. [Ronald, shift controller, Unit A] I really have no driving force other than [delivery due date], so I know I have got to meet a [delivery due date], that is my only driving force. [Vera, unit scheduler, Unit B]

Schedulers often reduce the complexity of their objectives to one simple goal – delivery performance. This simplification is a common behavioural strategy in the case of multiple contradicting objectives. Although schedulers across units and levels overtly indicate they prioritise timely delivery over other priorities, in practice there is strong pressure to maintain production continuity. This pressure is also relevant to justifiability, and will be further discussed in Section C (a) of this Appendix. Understanding this pressure contributed to understanding shared assumptions in the organisation, leading to scheduling decisions that do not support Lean practices, as discussed in Section 6.3.4.

(c) Time

Despite evident time pressure, scheduling team members often engage in analytical and group decision-making. Analytical decision-making is more time-consuming that intuitive decision-making, and group decision-making is more time-consuming than individual decision-making. Schedulers make decisions that can be justified, supported, and referred to in hindsight.

Table A.6: Time consuming decision-making

Analytical and group decision-making	We would do it as a team, just sit down and say "right, lets use some rational process". There are four basic tools which are: problem analysis, situation appraisal, decision-making and potential-problem analysis. Once you have chosen a direction, you can use the potential problem, what could go wrong with it and have some preventative actions and contingency actions. [Lee, planner and scheduler, Unit A]
Gaining approval of others	Sometimes you only have five minutes. You don't make the decision, obviously, in five minutes, but you've got five minutes to think about it, and have a quick chat with some other people, to get their opinion, in case there's something else thrown into the soup. [Ronald, shift controller, Unit A]

Choosing these time-consuming decision processes under time pressure indicates a need to avoid risks, blame, and criticism. This aspect of scheduling decisions highlights the influence of organisational blame on schedulers' decisions. Although schedulers are relatively autonomous when making decisions, consequences of these decisions are subjected to the feedback of others. This insight contributed to the understanding of schedulers' rejection of Lean practices in the face of organisational criticism over such practices.

Section C - Context

Contextual factors relevant for scheduling decisions were mentioned in all interviews, indicating that contextual factors are commonly relevant to scheduling decisions. The major contextual themes identified in this case are justifiability, and recent conditions. Shared assumptions relevant for scheduling were examined in detail in Section 6.3, and are therefore not presented in this appendix.

(a) Justifiability

Although the schedules are not reviewed by others, decisions that have an impact on other organisational functions (particularly production) need to be justified, or more than that – sold to them. This need to gain the endorsement of other organisational functions leads to a need to keep certain aspects of the decision available in the scheduler's mind.

> If you make somebody less happy, you have to be able to have an answer in your head, if they ring you up and ask: "why did you do that?" If you can give them an answer that makes sense, chances are they are going to go away. [Fred, master scheduler, Unit A]

Justifiability has been shown to promote status-quo and "safe" decisions. The need to justify scheduling decisions can lead to status-quo scheduling practices, such as maintaining large batches and high inventory levels. These status-quo decisions do not support the adoption of Lean strategy, which requires smaller batches and low inventory levels.

(b) Recent conditions

Schedulers at all levels maintain a mental image of the current situation of the plant. In some units, this image is supported by computerised visual tools, presenting the status of each machine. This mental image provides context for interpretation of new information regarding interruptions, updates, and changes to the existing situation. When an interruption occurs, in addition to resolving the problem, schedulers also prepare alternative plans for all possible events and their consequences.

> You need to know virtually every crane, fields, the whole works, what's in them, how much is in them, where you can play with putting feed, where you can afford to put feed. You need to know the whole plant, in detail. You always have to have lots of avenues, 'cause every minute something could go wrong and stop. [Ronald, shift controller, Unit A]

This mental image and awareness of recent events aids schedulers in their role as problem anticipators and solvers, presented in Section 5.1.3.

Appendix B. Lean strategy implementation management

One might claim that the implementation of Lean strategy in this case failed due to unprofessional or inappropriate change management. Indeed, failures of change initiatives are far from rare – a recent examination of success rates of change projects show that only 41% of change efforts meet all their objectives (Jørgensen, Owen & Neus 2009). Other change efforts either fall short of their objectives, or are discontinued prior to completion. However, in this study the implementation of Lean strategy was done professionally, by experienced change managers, who had ample resources and who dedicated time to educating the entire plant. This appendix shows that despite the presence of some generic change-management problems, a full understanding of the rejection of Lean strategy in this steel manufacturing facility involves the understanding of aspects specific to the adoption of Lean strategy in the steel industry.

Extensive literature on change management seeks to establish factors necessary for a successful implementation of organisational change (Weick 1995; eg., Kotter 1996; Cameron & Quinn 1999; Dawson 2003). Reviewing that body of literature is outside the scope of this thesis. However, a recent publication regarding the implementation of Lean strategy (Yauch & Steudel 2002) presents a list of prevalent factors supporting a successful change implementation. These are: clear definitions, effective communication and involvement, a sense of urgency for change, adequate resources, small steps, and effective rewards. The next sections provide evidence of how these factors were addressed by the implementing team, and show that this evidence does not provide a complete understanding of the failure to adopt Lean strategy in this case.

Section A - Clear definitions

Several aspects have to be clearly defined to support a successful change implementation. High-level aspects involve a vision, purpose, goals, and strategy. Low-level aspects concern performance criteria and measurement systems. Organisational aspects involve roles, structure, and authority. The implementation team was highly aware of the need for clear definitions. In addition, the organisation studied has a low tolerance of uncertainty, and thus change initiatives typically address clarity of definitions. Evidence of the clarity of definitions in this case is provided in Table B.1.

Table B.1: Evidence of the clarity of definitions

Definition	Evidence
Vision and purpose	Key Message in Communications: This project is not about just reducing inventory, it is about continuous improvement and getting product to our customer faster. [Project summary document]
Strategy and goals	• Target: 1/2 week of safety stock and 1 week of replenishment orders in finished goods. • Replenish only what gets shipped from the finished-goods kanban [Mill finished goods summary presentation]
	• Focus on how quickly product moves from forecast to invoice • Small-step improvement process • Manage by having goals, action plans & monitors • [Enforce the] kanbans [Institutionalisation of Lean strategy in the Mill]

Performance criteria	Introducing "Days of inventory" (DOI) as a measure of lead times: We introduced "days of inventory" as a measure. Nearly everybody in the whole company still has that measure in their bonus today [Cameron, program director, the mill] We were looking at "work in progress", finished goods inventory status; on-time delivery, quality, performance, and days of inventory in total. We then relate that back to daily decisions. [Fiona, project manager, the mill]
Procedures	Form – "Authority to exceed kanbans"
Clear roles and authority	We made sure that we had meetings with the senior management team at the Mill every week. [Fiona, project manager, the mill]

(a) High-level definitions

Definitions of the vision, purpose, strategy, and goals were evident in several implementation documents and presentations. These definitions were stated at the beginning of most internal implementation documents, providing context and understanding of the goals and purpose of the project, and the strategy of the implementation.

(b) Low-level definitions:

Performance criteria were defined and aligned with the Lean objectives. The measure "days of inventory" reflected how long a product resides in inventory prior to delivery. This measure is directly linked to lead time, and the team made this relationship clear, as well as the relationship between this measure and daily practices.

(c) Organisational definitions

Daily practices were restricted by procedures, exemplified by kanban adherence. The procedure for exceeding a kanban was made clear to schedulers and a form specifying why a kanban needs to be exceeded attests to the clarity of the procedure for exceeding it.

Finally, the implementation team drew on the authority of the units' top management. This authority was established initially when the unit's top manager adopted Lean strategy, and was reinforced by weekly team meetings. This authority was useful while implementing training programs, maintenance practices, and kanban adherence.

This evidence demonstrates that the implementation team clarified definitions both internally, amongst themselves and senior management, and externally to the workers in the unit. The implementation team thoroughly addressed this aspect of change: high-level, low-level, and organisational issues were clearly defined. The way these definitions were communicated, as well as other aspects of Lean strategy, is presented next.

Section B - Effective communication and involvement

Effective communication of the upcoming changes and involvement of organisational members in the change processes are known to support organisational change (Hackman & Oldham 1980; Kotter 1996). Both promote employee commitment, acceptance, and understanding of the change.

The implementation team placed a strong emphasis on communication throughout the implementation. After the initial introduction of the upcoming change

and its meaning (i.e., reduction of inventory), the implementation team ran workshops to train and educate all unit members by familiarising them with Lean theoretical principles and practical aspects. Unit managers went through a two-day workshop, and operators went through a half-day version. In addition to these workshops, which were run at the beginning of the program, awareness sessions were run prior to the introduction of each practice change. These awareness sessions were designed to familiarise and alert individuals of the nature of the change and the logic behind it. Packages of written material were handed out at the end of these sessions, making the information available and accessible.

The implementation team aimed to make sure at least 85% of the unit members were familiar with each new practice. To achieve this aim, a log of all participants in all workshops and awareness sessions was kept and displayed. Evidence of these communication practices is presented in Table B.2 below.

Table B.2: Evidence of effective communication practices

Teaching theory of Lean strategy	We'd do a lot of theory about push/pull, about forecasting, about batch sizes and some basic fundamentals of Lean strategy. [Cameron, program director, the mill]
Practical demonstration of Lean principles	We ran a game demonstrating the difference between push and pull. [Using "Push" strategy] we could make 2 colours of houses in 10 minutes and now [using "Pull"] we can make 49 colours of houses in two minutes. They were enjoying having to cut things out. By the end of the game they felt better about Lean strategy. They were happy that it worked. [Cameron, program director, the mill]
Communication of implementation steps	We had a lot of communication packages developed to hand to people. Before we started implementing anything, we would hold 45-minute awareness sessions, and in the end, hand out the package. [Fiona, project manager, the mill]

Members' training follow-up	We set targets and we measured how many people were trained. I'd also plot how many people had been trained on a particular technique that we'd need to get going. Our goal target was to communicate to 85%. We made sure that we were 85% or above. We made sure that we didn't lose somebody. [Fiona, Project manager, the mill]

The implementation team took the training session very seriously, and key individuals who refused to attend workshops or sessions were not let off the hook. The following quote describes a creative and humorous way employed to enforce participation of a particularly resistant manager:

I went to the ambulance station, hired a wheelchair and said to him, "I'm going to drive you today!" He was all embarrassed. He wouldn't let me use the wheelchair, but he did walk out [and joined the workshop]. [Fiona, project manager, the mill]

In addition to a one-way communication of the change, the implementation team sought to *involve* unit members in the implementation of the change. *Involvement* is defined as employees' exercise of influence on how their work is carried out (Morgan & Zeffane 2003). In accord with this definition, employees were involved by eliciting their input and enabling that input to influence their work. Lean strategy prescribes lower levels of inventory, and standardised batch sizes. Managers and schedulers negotiated the new inventory levels, and were asked to determine the appropriate standard batch size. When the implementation team realised such a size could not have been determined, they abandoned that aspect of Lean strategy and focused inventory levels, which were less controversial and easier to implement.

We went through an exercise - how big should the batch be? The operating guys spent quite a bit of time [trying to determine it]. After about six months of trying real hard, they couldn't work out the batch size. Because they

couldn't give me any answer about that, we approached it from another point – how long should a product take to process. [Ian, team leader, the mill]

This quote, and the process the team leader went through, demonstrates how the implementation team adjusted principles of Lean strategy to suit the needs and conditions of unit. The implementation team did not simply dictate the terms of the change, but modified the implemented principles according to unit members' input.

In addition, managers requested an information system that would assist them with the adoption of the new practices. This system was developed to support the schedulers' and managers' information needs, and to enable them to relinquish inventory that served as insurance. It was developed quickly and effectively: it is still in use today in the organisation, attesting to its success. The next quote demonstrates these aspects of involvement:

We [project team] used to say to people: "We want you to live with less inventory. What would make your job easier?" They'd say, "If I could get information on this, that would be really good". We'd go and deliver this brand new system for them. No questions asked, no business case, no bureaucracy. We'd just do it. Within days these people had a system that did what they wanted. They had this new information they helped design. This system is still in use today [Cameron, program director, the mill]

This section shows that managers and operators were trained and educated regarding Lean strategy, and that every step of the program was announced and clarified prior to its implementation. Theoretical and practical material was summarised and handed out. Targets and strategies were clearly defined and communicated consistently throughout the unit. Unit members were involved and consulted in order to adjust the change and the systems, to support their needs. This section shows that the rejection of

Lean strategy was not due to lack of knowledge of this strategy, or due to poor communication.

Section C - Adequate resources and support

This project enjoyed ample support and funding from when the implementation team was trained (i.e., 12 months before the actual implementation), until 18 months after the implementation. After 18 months, the top manager left the unit, and the lack of support from the new top manager enabled the decay of Lean strategy enactment. This section provides evidence of the degree of the support that was available prior to the change in management, and shows how the change in management led to the rejection of Lean strategy.

Naturally, projects with insufficient resources would struggle to survive. Resource allocation often depends on top management support and political sponsorship; however, such support and sponsorship can extend beyond tangible resources (Yauch & Steudel 2002). As with many change initiative, top management support is necessary for successful supply-chain management initiatives (Gunasekaran et al. 2004). Political sponsorship can help remove roadblocks and advance change initiatives, since political behaviours inevitably accompany organisational change (Price, Lavelle et al. 2006).

This project had both top management and political support. Top management was present in weekly performance-monitoring meetings. This involvement assisted with enforcing Lean practices, as explained in the quote below:

> The brief on Monday meetings had the senior [manager], which was very powerful, and people knew they had to have a pretty good explanation if there was a major deviation from the targets. Those targets were very visual, particularly the amount of "work in process". [Vincent, project manager, the mill]

The implementation team had ample financial support, as they were part of a corporate-wide program of Lean implementation. This support assisted with practical aspects necessary for the implementation, such as the development of the information systems discussed in Section B of this Appendix. The next quote demonstrates the support of corporate finding.

> We'd go and [build an information system] because I had corporate funding, and I had two programmers that work for that. We'd go and deliver this brand new system within days. [Cameron, program director, the mill]

Corporate funding also enabled the implementation team to undergo a thorough training with world-class experts, over a period of 12 months. Perhaps the most convincing evidence for adequate resources is the absence of evidence for a *lack* of resources. The possibility that additional resources were necessary was not raised in any interviews or informal conversations.

In additional to practical and financial support, the implementation team elicited the political sponsorship of senior, credible top managers in the organisation. These members are clearly described in the following quote:

> Sponsors are the senior people who provide guidance; give [the project] credibility, and help with roadblocks. Once a month I would go to my sponsors and ask for their help and their counsel. If I ran into a roadblock I could go to my sponsors and explain my roadblock. They might be able to give me some counsel. They might say, "Let me give them a call", or perhaps, "Have you thought about this approach?" [Cameron, program director, the mill]

These quotes demonstrate the availability of funding to the project team, the guidance and support of senior credible members, and the support and follow-up of the mill's top manager.

Although political support was present, it was no longer effective once the mill's new top manager was appointed. The new top manager was not committed to implementing Lean strategy. His rejection of Lean strategy reduced the reinforcement of Lean practices, which eventually resulted in performance deterioration.

> [The new plant manager was] a very highly regarded production guy. He had the view that the problem at the mill was caused by poor quality. He focused on less errors, higher yields. He allowed kanbans to be broken and didn't follow up. [Inventory levels] went up a bit: he didn't do anything about it. [Cameron, program director, the mill]

Although the lack of support from top management contributed to the rejection of Lean strategy, it does not provide a complete explanation for the consistent resistance this strategy encountered in this organisation. By the time the new manager was appointed, Lean strategy had been in place over 18 months. However, the resistance to Lean practices predated this appointment. When top management support was lost, resistance forces overpowered the efforts of the implementation team, but the underlying causes for this resistance cannot be explained by the management turnover. This case demonstrates that the pressures to reject Lean strategy in the steel industry stem from more fundamental issues.

Section D - A sense of urgency for change

A sense of urgency has long been identified as an important element for a successful change (Kotter 1996). It gives organisational members a strong drive to make necessary adjustments. Although the implementation team strove to install this sense of urgency, they were unsuccessful.

The sense of urgency to improve the mill's performance could have been driven by the fear for its survival. The mill had been under threat of shutting down for several

years. Fierce overseas competition had undermined the plant's financial viability, and employees were in constant fear of losing their jobs. The rest of the steelworks in the area were undergoing extensive downsizing, and the workforce had been reduced from 20,000 to less than 5,000 employees. Thus, the fear of job loss was not unjustified.

Many of the workers lacked formal education, and their expertise was a result of many years of work in the plant. Few employment alternatives would have been available to these employees had they lost their jobs, as the organisation was the major employer in the region.

Employees' fear of losing their jobs was sufficient to lead to their support of business survival; however, organisational members often mentioned another important reason for wanting the plant to continue: pride in being a local manufacturer of goods, as demonstrated in the next quote:

In the big picture, when we have a can of beetroot, we can sit with our family and say, "hey guys, this is tin plate from Australia, made by Australian workers". But we can't say that, now that the plant is shut. [Vincent, project manager, the mill]

These fears of the plant loosing its economic viability could have served to provide organisational members with a sense of urgency to achieve a successful change. Improving operational performance in the mill would have brought along financial benefits, and such improved performance could have justified continuing its operation. This angle was communicated to unit members; however, this did not create the sense of urgency required for them to be engaged in the new strategy, and did not elicit their support, as demonstrated in the following quote:

We said, "Guys, we're here for the survival of the business. We're here to improve the business, so we can all have a job". But I don't think they actually believed that the

business was in trouble. They just couldn't see the picture. The business itself was in denial that they were in trouble. They've been told they're in trouble for the last five, six years. "Guys, you're not making any money", "Yeah, heard that before". People were in denial. [Vincent, project manager, the mill]

This quote shows the attempt to instil a sense of urgency in members of this plant, and the project managers' retrospective view indicating this sense of urgency was not present despite these attempts. A sense of urgency is usually considered a motivator to undergo the discomfort involved in change, providing the initial thrust of energy to promote the change. However, the progression of change in this case demonstrates that despite this lack of urgency, the change gathered momentum by the energy of the implementation team, and by achieving initial successful results. Therefore, the lack of a sense of urgency does not fully explain the forces that undermined the sustainability of Lean strategy in this organisation.

Section E - Small steps and short-term success

A comprehensive change can be a long process, which requires long-term efforts. Short-term wins and successes maintain the momentum for such a lengthy process (Kotter 1996). The implementation team was aware of this, and accordingly, broke the change up into small manageable steps. Each step was introduced by an awareness session, described in Section B of this Appendix. Furthermore, the team operated against common stagnant organisational approach, and implemented ideas immediately, to gain momentum:

[We] broke it up so that each major production unit was a separate project. It started off by having a small team working with Vincent, who engaged people in the production unit. Rather than analysing to death any suggestion, we had people walking out the room and doing stuff straight away.

That created a [momentum]. [Fiona, project manager, the mill]

The team made use of small successes: the successful results from each step were made visible by recording success stories in a field book. The effectiveness of these successes was further reinforced by the plant manger himself:

Owen made it his business to go and sell it, to ask questions about it all the time. He'd go in and say – "Isn't it good what so-and-so has done. Now what are you doing?" [Ian, team leader, the mill]

Success was demonstrated through visual display of achieved targets, such as reduction of days of inventory, as well as by demonstrating performance improvements in some units. The reduction of inventory resulting from Lean strategy made the facilities tidier and more pleasant to work in. This success created an initial momentum and support of the change:

We were seeing very positive results in terms of the reduction of inventory, and the housekeeping was fantastic. Everybody got a big buzz out of it, even the operators. That was a wave of "this is good". [Vincent, project manager, the mill]

However, these successful results did not elicit conviction among all unit members, and did not sustain the implementation. Managers' old convictions were too strong, and the success of others was not sufficient to elicit their support of Lean strategy.

We had about six in-line process managers, and there was varying levels of acceptance. [For example, one manager] was very much in support of it, a very strong advocate. We started there and proved to others that this had been successful. But it didn't seem to impact on other people. They couldn't make the shift from what they've been doing in the past to the suggested changes. [Vincent, project manager, the mill]

This case provides evidence that small steps and short-term successes are relevant to the *successful* implementation of a change. However, they may not have a sufficient impact on the *sustainability* of this change. This section demonstrated that while small steps enabled a visible progress in the change, and the celebration of short-term success created the expected momentum, in the long run they did not create the necessary change in intuitive decision-making to support Lean practices.

Section F - Effective rewards and incentives

Organisations reward behaviours and activities in many ways. Financial incentives are universal, and, as explained in Section 2.6.2.3, require adjustment when Lean strategy is implemented. Other rewards and incentives, such as promotion opportunities and recognition organisation-wide, are not as simple to adjust, as they involve individuals and systems that are beyond management's control. Financial rewards, although addressed, did not hold the key to a successful and sustainable change in this case. Social and promotion-related rewards proved far more sustainable, and their influence was detrimental to the success and sustainability of Lean strategy.

(a) Financial rewards

In this unit, a fundamental revision of rewards was not possible. As discussed in Section 5.2.2.7, the rewards in this organisation needed to reflect performance that depended solely on the evaluated individual, and not the individual's impact on overall performance. Therefore, many of the performance measures were unchanged, as the following quote explains.

> That's the way that the business was set up: the guys working in the unit were responsible for the unit's costs. They didn't feel like they were responsible for the total costs in the business [Ian, team Leader, the mill]

However, the implementation team was able to introduce a performance measure that reflected Lean principles: Days Of Inventory (DOI). This measure examines how long inventory remains undelivered. It reflects production lead-time, and is parallel to the "early" measure in early-tardi scheduling problems (Baker & Scudder 1990). Having this measure included in individual performance measures raised the awareness of the costs of work-in-process inventory, as demonstrated in the following quote:

[We made] days of inventory [a part of] everybody's bonus. Having it in the measures was important. It made people believe that it mattered. But I'm not sure the money itself mattered. [Cameron, program director, the mill]

This measure did not have a great impact on individual salary. The speaker addresses that point by saying the money itself may have not mattered. Supporting evidence for the speaker's view was found in interviews with contemporary schedulers. All contemporary schedulers claimed that the bonus component of their salary did not drive their decisions. For example, the master scheduler in Unit A explains how his bonus component, determined meeting production targets and reduced inventory levels, was reduced last year:

Unfortunately somehow they both missed. I still to this day don't understand how that happened. All I can do is give good schedules to the line. You still do the right thing by your company, even though I should have been [aligning decisions with my incentives], I am not going to do that. It doesn't work like that. [Fred, master scheduler, Unit A].

In addition to financial recognition, production quantities (and not reduced inventory) entail personal, social, and professional rewards. In this setting, a fundamental cultural change would have been required, to reduce the importance attributed to producing large quantities. This change was beyond the ability and the timeframe of this implementation team. However, it is an important mindset that needs

to be acknowledged when implementing Lean strategy in the steel industry. The next quotes demonstrate how important large quantities are in this industry.

> There's a thing around here they call "production records": who's made the most tonnes in a shift. It's a bit thing, when someone sets a new record. [Ian, team leader, the mill]

> They [production managers] are tremendously proud of it and the promotion system respects it. The guys that get promoted are the ones that break records. [Cameron, program director, the mill]

In summary, although rewards and incentives were revised to include Lean principles, culturally embedded rewards overpowered their effect. These culturally embedded elements are part of the factors impeding a successful and sustainable adoption of Lean strategy in the steel industry, as discussed in Section 5.2.1.4.

Section G - Summary

When examining how the implementation was managed, it is evident that it was managed professionally, by experienced change managers. The implementation team addressed and was aware of central change management principles. The implementation team clearly defined their vision, purpose, goals, and strategy, and communicated them consistently, comprehensively, and extensively. The implementation team involved the workers and acknowledged their contribution, and when necessary used their input to adjust the change efforts. The implementation team had ample resources and support. Finally, the implementation team created and celebrated short-term wins and successes.

However, despite these efforts and awareness, several aspects critical to successful change management impeded the implementation of Lean strategy in this case. First, the implementation team was unable to instil a sense of urgency in the unit, as threats of shutting down the unit had been present for years before. Second, top

management changed after about 18 months, and the new management was not committed to or accepting of Lean strategy. Finally, rewards and incentives were modified to include Lean principles; however, their influence may have been minor in comparison with the social and cultural rewards in this organisation.

These impeding conditions undoubtedly played a role in the rejection of Lean strategy in this organisation. However, these impeding conditions do not fully explain the forces leading to this rejection. First, despite the lack of a sense of urgency, the implementation was initially successful. Thus, the changes brought about by Lean strategy were accepted and adopted despite possible complacency. Second, the change of management occurred relatively late in the implementation. During this time, improved performance demonstrated the benefits of Lean strategy, yet Lean scheduling practices were subjected to continuous resistance. Thus, a change of management merely removed the enforcement of Lean principles. However, this does not explain the rejection of Lean scheduling principles throughout the implementation. Finally, the social and cultural rewards in the organisation go hand-in-hand with the factors uncovered in this thesis that explain this persistent resistance to Lean principles.

These three factors – a lack of sense of urgency, top management turnover, and traditional regard for large quantities – are common in the steel industry. A full understanding of their impeding influences on the adoption of Lean strategy could benefit future efforts of such implementations. This thesis does not reject change-management theory, but supplements its principles with concepts that are peculiar to the adoption of Lean strategy in the steel industry.

Appendix C. Interview protocols

Section A - The mill case study – interview questions

(a) Background questions

- How long have you been working in [this organisation]?
- How long were you working in the mill?
- What was your role in the mill?

(b) The introduction of SCV*

- How was the change introduced?
- What was the focus of the change? (reduce inventory, improve quality, improve response time, improve productivity, other)
- Who was trained? (managers, employees)
- What was the core message of the training?

(c) The implementation of SCV

- - How did it work? What were the physical changes?
- - What was the reaction of managers and of employees?

(d) Acceptance of SCV

- What aspects of SCV were favourably accepted?

(e) Resistance to SCV

- Resistance: what was the nature of the concerns?
- How were the concerns expressed?

(f) Failure of SCV

- How did it fail? What were the first things that stopped working?
- Was the change in mill management unavoidable?
- Was the success only dependent on management?
- How did performance get worse? What caused the deterioration?

(g) Lessons

- What kind of implementation would have avoided failure?

*SCV - Supply Chain Velocity, Lean strategy

Section B - Contemporary scheduling – interview questions

(a) Background

Q1: Ask questions about the person's background, history and role in their current position. *[What relevant supply chain and scheduling experience have they had? Jobs, education]*.

Q2: In a few sentences, please describe the role of your unit in the overall [company] supply chain. What are the unit's core products / services? *[Understanding decision's context]*

Q2a: Would your answer be any different 12 months ago?

Q2b: Do you expect your answer to change within 12 months? *[The influence of recent supply-chain changes]*

Q3: What is the nature of the decisions you need to make on a routine basis? *[Understanding of the role of the individual in the decision process]*

Q4: To help guide the rest of the interview, please describe your role in the process of decisions. What is your area of responsibility? *[Understand the individual's role and responsibility]*

Q4a: Would your answer be any different 12 months ago?

Q4b: Do you expect your answer to change within 12 months? *[The influence of recent supply-chain changes]*

(b) Nature of decisions made in unit

This section aims to capture the nature of decisions being made, as well as the situation in which these decisions are typically required.

Q5: If I was a new person to work in your role *[Master Scheduler]*, and you were my trainer, how would you describe to me the goals of a schedule? *[Getting an understanding of the main goals of production scheduling decisions]*

Q5a: Please describe the typical "baseline" decisions made in your unit. What is the typical decision you are required to make? *[Getting a picture of the typical decision]*

Q5b: What are the main goals your schedule should achieve? What are the main key performance indicators (KPI) taken into account? *[Getting a picture of the goals and drivers of production-scheduling decisions]*

Q5b1: Would your answer be any different 12 months ago?

Q5b2: Do you expect your answer to change within 12 months? *[The influence of recent supply-chain changes]*

Q6: What are typical mistakes made in this role, by novices? What is the consequence of these mistakes? *[Understanding negative consequences]*

Q7: Please describe the typical interruption requiring an adjustment of your initial decision. *[Understanding unexpected influencing events]*

Q7a: What percentage of these interruptions is unforeseen events, versus overdue information?

Q8: What is the level of discretion you have in making these decisions? How much is pre-dictated? *[Capturing the role and input of the individual]*

(c) Task-related characteristics of decision

This section aims to provide understanding of task related influences: time available, information, presentation, and availability.

Q9: Please indicate how much time you typically have to make a routine decision. How much time is available for consultation with others, information gathering, comparison of different options and their consequences? *[Searching for variance in time available to different decisions-makers]*

Q10: Please indicate the key information typically available to you at the time of scheduling production. *[Perceived information needs for a decision – to be compared with information required for optimisation of schedule]*

Q11 Who do you consult when making a decision? *[Search for other sources of information and influence]*

Q11a: How frequently do you communicate with the following parties? (Please fill table C.1)

Table C.1: Information sources and influences for production scheduling decisions

Function	Frequency	Weighting
Production		
Maintenance		
Quality		
Logistics (Dispatch and Delivery)		
Customer Service (Ordering)		

Q12: Please indicate the format of the various information items (i.e., is the information directly accessible via information system, does the information need to be calculated, or does it need to be verbally requested) *[Searching for presentation bias and availability bias]*

Answers to questions 10-12 are expected to fill Table C.2.

Table C.2: Production-scheduling decisions information descriptions

Information	Source and Format	Availability

(d) Individual-related characteristics of decision

This section aims to provide understanding of individual influences such as incentives, experience, and decision motivators.

Q13: What objectives guide your decisions?

Q13a: Among the drivers of your decisions, which are related to your performance indicators (KRAs)? *[Understanding the role of individual financial incentives]*

Q13b: Which financial incentives apply to your role? What are the financial measures your role is estimated on (STIs/ BIIs)? *[Understanding individual financial incentives]*

Q13c: Among the drivers of your decisions, which are related to the performance indicators of your superior (KRAs)? *[Understanding the influence of supervisory drivers]*

Q13d: What other motivators drive your decisions? *[Gaining a full picture of the drivers]*

Answers to questions Q13a-Q13d are expected to conform to Table C.3.

Table C.3: Organisational levels and motivators categories

Organisational Level	Time Horizon	Time Buckets	Decisions Drivers	Number of Individuals
Sales and Operations Plan	1 fiscal year	Months / Weeks	High-Level Budget Planning	~5
Master Production Schedules (Master Schedulers)	3 months rolling	Weeks	Customer Priorities: • Profitability of products • Delivery history Maintenance Requirements: • Backlog elimination: •	~5

Production Plans (Unit Schedulers)	1 week	Daily	Delivery performance (DP): • Cut-off time for delivery • Carrier availability • Order size (small orders are easier to achieve) Utilisation: • Maximise throughput rates • Minimise number of changeovers • Minimise duration of changeovers • Minimise movements – preference for accessible feed material/delivery material Inventory Levels (DOI): • Reduce inventory levels •	10-20
Production Schedule (Shift Controllers)	2 days rolling	Hourly	Utilisation (see above) Inventory Levels: • Availability of space • Minimise movements: accessibility of storage space	~100

Q14: What part of your decisions is imposed on you? How are they imposed? *[Understanding organisational control mechanisms and their influence on individual goals]*

Q15: Which career paths are available to decision-makers in your role? To what extent do you think they influence how you make your decisions? *[Understanding the role of career aspirations as part of individual goals]*

Q16: When you consider possible events, what is the worst possible situation under which a decision has to be made? *[Understanding what is being avoided]*

Q17: Please describe a few "bad" scenarios in terms of unexpected events. How often do these events occur? How seriously are they taken into account when a decision is made? *[Understanding negative consequences to be avoided]*

Q18: Over time you must have developed a method of making these decisions. How would you describe it? *[Individual experience: developed heuristics]*

Q18a: How long does it take to develop this understanding? *[Individual experience: tenure]*

Q18b: What previous roles in this organisation provide useful background to this role? *[Individual experience: different units]*

(e) Context-related

This section aims to understand context related factors and their influence on production decision-making.

Q19: Does anyone review your decisions? To what extent is that kept in mind when decisions are made? How does that affect the way decisions are made? *[The role of a need to justify]*

Q20: Who is affected by your decision? How does that impact on your decision? *[the role of social context]*

(f) Concluding Questions

Q21: Please describe major relevant decision aspects which have not been covered in this interview.

Q22: Have you got any questions?

Q23: Do you agree to be contacted again for further clarification and additional information?