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Managing Decision-Making Bias in ERP Use by SMEs

Connie L. Kahler
University of South Florida, conniekahler@ymail.com

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by

Connie L. Kahler

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Major Professor: Matthew Mullarkey, Ph.D.
Co-Major Professor: Alan R. Hevner, Ph. D.
Donald Berndt, Ph. D.
Ron DeSerranno, D.B.A.

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ABSTRACT

The purpose of this study was to examine the use of ERP and outputs by six decision-makers in one SME manufacturing organization and provide artifacts targeted to improve their pricing decisions. Through elaborated action design research, we collected data to diagnosis decision-makers concerns and identified decision making biases and errors. Using insights obtained and collaboration, we designed, implemented and evaluated seven artifacts targeted to minimize four biases identified – overconfidence bias, optimistic bias, planning fallacy and representativeness.

The data collected during the diagnosis phase revealed that concerns fell into three primary themes: data, human interfaces, and cognitive bias. The seven combined artifacts implemented had a positive impact minimizing bias in this organization. This research revealed how artifacts such as policies, procedures, processes, reports and system modules help SME decision-makers mitigate cognitive biases and errors. Additionally, this study confirmed that the eADR process can be an effective means of implementing incremental changes, evaluating impacts and increasing engagement in this environment. Limitations of this study include concurrent introduction of artifacts, single SME organization and embedded nature of the researcher.

CHAPTER ONE:
INTRODUCTION

I recently joined a small manufacturing company as a financial executive. The organization reported a less than desirable financial performance and a quick review of the income statement showed low profit margins to be one of the culprits. Upon further investigation, I noted that the pricing methods were peculiar. The development of a price can be a top-down approach depending on what the market will bear or a bottoms-up approach that begins with cost then adds a reasonable markup to cover expenses and produce a profit to determine a price (Horngren, Datar & Rajan, 2015).

This small-to-medium enterprise (SME) used a quasi-method with a simplified bottoms-up calculation and reduced prices for a variety of reasons. For example, Sales stakeholders reported estimated labor costs were often *too high* and then reduced the estimated hours within the bid calculation. This reduction did not reflect experience but rather a *feeling* that the price should be lower. Other components changed when someone recalled stellar performance on a similar job. Sometimes the reasons for price changes were difficult, if not impossible, for the decision-maker to explain at all.

The organization could not sustain itself without generating profit. As an employee, I was highly vested in its survival. I found the financial performance at this SME especially surprising because the organization had an Enterprise Resource Planning (ERP) system in place. Such a system could provide a centralized source of information and support for decision-making.

However, members of the organization did not rely upon it in the same manner as the larger firms I worked with in the past.

I was curious to understand why these decision-makers, when determining a sale price, chose as they did. Personally, I wanted pricing decisions to boost profit margins and increase the likelihood of the firm's survival. I recognized a unique opportunity to investigate decision-making biases in an SME environment.

Small businesses and entrepreneurs operate in situations that are new, unpredictable, complex, and likely to produce information overload (Baron, 1998). Prior researchers outlined the conditions that are most likely to exacerbate cognitive biases (i.e., when information overload occurs, situations are new with a significant degree of uncertainty, emotions run high, and time pressures are present); therefore, cognitive biases influence many decisions in small businesses (Gilbert, McNulty, Giuliano, & Benson, 1992; Fiske & Taylor, 1991; Kahneman, 2011; Oaksford, Moreris, Grainger, & Williams, 1996; Wyer & Srull, 1994). Kahneman and Tversky (1972, 1979) and Kahneman and Lovallo (1993) identified four heuristics and systematic flaws in thinking that are likely to appear during risky and uncertain scenarios:

1. Overconfidence bias: the belief that personal judgments and predictions are more reliable than they are.

2. Optimistic bias: the belief that an employee and an organization are less at risk of experiencing negative outcomes than others.

3. Planning fallacy: the underestimation of an aspect of a task (e.g., time required or costs anticipated) due to an overly optimistic viewpoint.

4. Representativeness bias: the overestimation of the degree to which a small sample reflects the characteristics of a total data set.

Enterprise resource planning (ERP) systems integrate operational, manufacturing, sales and accounting functions and provide decision making benefits to organizations (Staehr, Shanks, & Seddon 2012). I witnessed these benefits first-hand during my career of working in large enterprises (LE) where ERP systems commonly exhibited positive benefits. However, unlike my prior LE experience, this organization did not seem to reap those benefits. In fact, the ERP was not effective in this SME environment. It was limited to a small number of employees and primarily reserved for transactional processing. The ERP had minimal influence on the decision-making process rather than being a tool to enhance or expedite it.

Research Questions

Given the existence of cognitive bias in this SME environment and the use of an ERP system, I developed research questions to investigate the problem and provide solutions. The research questions that guided this study were as follows:

RQ1. How and why do SMEs use ERP systems and outputs in effective ways as part of their decision-making process?

RQ2. How can I provide an artifact(s) that will improve price decision-making in this SME organization?

The purpose of this study was to examine one SME manufacturing organization's pricing decisions and the use of ERP outputs by decision-makers. This research is descriptive and prescriptive in nature. The intention is to reveal factors that influence decision-makers at this SME to rely on ERP information. The research method included an intervention and creation of artifacts to increase the utility of the ERP system for this organization. This study may help this organization and contribute to future research by investigating methods to lessen cognitive biases in a real-world SME setting.

Research Justification

This research was necessary for several reasons. The significant role that SMEs play in the current U.S. economy make this research topic relevant (SBA, 2018). Solutions to the research problem are unclear, which further supports the need for this investigation. This research problem provided an opportunity to fill gaps in the existing literature related to SMEs and ERP systems (Haddara & Zach, 2012; Verbano & Venturini, 2013).

The U.S. Small Business Administration's (SBA, 2018) small business profile described the significant role SMEs play in the current U.S. economy. Based on the 2017 census, small businesses employ 57.9 million people and comprise 47.8% of the private workforce (SBA, 2018). Despite employing such a large segment of the workforce, their existence is quite volatile and only half survive more than five years. Furthermore, CB Insights (2018), a venture capital database, found that 18% of SME failures were due to pricing and service problems. Small businesses are the source of employment for just under half of U.S. workers and pricing inaccuracies are one of the top 20 reasons they fail (SBA, 2018). Therefore, the present study was warranted.

Despite the quantity of SMEs, their increased use of ERP systems and an environment ripe for cognitive biases, this topic is not well understood and solutions are unclear. Significant research exists on ERP system use in large organizations, but SMEs are not like their larger counterparts (Welsh & White, 1981). There are several differences between large and small companies' adoption of ERP systems (Buonanno, 2005; Laukkanen, Sarpola & Hallikainen, 2007). For example, SME employees often perform multiple roles rather than the specialized task delegation researchers observed in larger firms. SMEs may lack history, unlike their larger

more established counterparts, and operate in rapidly changing, uncertain environments. Policies and procedures that govern employee actions are typically informal (Buonanno et al., 2005).

Despite these obvious differences, a literature review on SMEs and ERP systems revealed that unlike LE, research related to SME and ERP is limited. Only 27 publications investigated the use and maintenance of ERP systems in SMEs (Haddara & Zach, 2012). This gap in the literature supports the need for research on this topic. Furthermore, Ojala, Vilpola and Kouri (2006) recommended that "benefits and risk be re-assessed once or twice a year to govern system usage and avoid slipping into old procedures" (p. 183). There is no research on the post implementation use of ERP by SMEs that specifically investigates how to counter decision-making biases in this unique environment. The convergence of SME, ERP, and decision-making bias is not well understood and further research was necessary.

This dissertation specifically answers two calls for research. In general, there have been calls for increased research on ERP systems emphasizing the full lifespan of the system beyond implementation (Grabski, Leech, & Schmidt, 2011). Haddara and Zach (2012) noted only two action research (AR) studies of SMEs and ERP in their extended literature review. "AR and other engaged methods could provide valuable hands-on experiences for ERP in SMEs literature and practice" (Haddara & Zach, 2012, p. 113). This research provided the ideal opportunity to meet both requests.

Research Significance

The summary of findings from this research may contribute to several areas. Due to the persistence of cognitive biases, research that validates or expands knowledge for methods to mitigate them remains important from a scholarly perspective. Because I conducted this research in a real-world setting, the findings may be generalizable and inform SME leaders and decision-

makers, making it of practical interest as well. This research expanded my personal understanding of this topic, which increases my effectiveness at the organizations I serve and my areas of interest.

Summary

In conclusion, I investigated how and why SMEs use ERP output in their decision-making process and developed artifacts that specifically combat cognitive biases in this unique environment. I conducted this AR in a real-world setting at one SME located in the United States. The focus is SMEs, a significant employer of the U.S. population, ERP systems, and decision-making biases. Past researchers identified both the topic and method of investigation as necessary (Haddara & Zach, 2012). Practical and scholarly contributions resulted from this research.

CHAPTER TWO:

LITERATURE REVIEW

This research was an attempt to solve a real-world problem. The purpose of this chapter is to provide an overview of the existing literature as it relates to the topics of small businesses, ERP, and decision-making bias. Because of the extensive literature associated with each area, I begin by operationalizing SMEs in the context of this research. This format allows a more succinct dissection of the ERP theme and current knowledge regarding decision-making bias in this environment. This chapter concludes by explaining how this research will fill some gaps in the current understanding of this topic.

Small and Medium Enterprises

In the United States, SMEs are companies with a certain annual number of employees or average annual receipts for a three-year period (Small Business Size Regulations, 2018). In U.S. manufacturing, the SBA guidelines define SMEs as having less than 500 employees (Small Business Size Regulations, 2018). Small and large business are not the same (Welsh & White, 1981). A distinction between LEs and SMEs positioned the present research within the context of financial risk, which is significant for small business and has a direct bearing on survival rates. Past researchers extensively studied LEs and SMEs have unique characteristics that require more specific investigations (Haddara & Zach, 2012; Grabski, Leech, & Schmidt, 2011). Despite employing over half of all U.S. workers, SMEs are susceptible to failure. The most recent U.S. census data reflected that only half of SMEs remain in business for more than five years (SBA, 2018). Therefore, SME research is highly relevant.

Welsh and White (1981) coined the phrase *resource poverty* to describe the environment in which SMEs often exist. Small businesses typically operate in highly fragmented industries in which competition is high and resources for internal expertise and training may not be readily available. Furthermore, liquidity and pricing/cost issues cause 29% and 18% of SME failures, respectively (CB Insights, 2018). In fact, CB Insights (2018) concluded, "Pricing is a dark art when it comes to startup success, and startup post-mortems highlight the difficulty in pricing a product high enough to eventually cover costs but low enough to bring in customers" (p. 19).

SMEs, unlike LEs, make decisions at a rapid pace and have higher tolerance for risk (Lindegaard, 2015). Surprisingly, Ernest and Petty (1978) reviewed liquidity variations between small and large firms and found small firms to be more profitable. However, their findings may be due to the sample (i.e., small firms on the cusp of an initial public offering). Most small businesses focus on survival during the initial stages and solid decision-making is critical. As Welsh and White (1981) concluded, "small businesses can seldom survive mistakes or misjudgments" (p. 18).

Several comprehensive literature reviews facilitated my understanding of small business concerns. In the context of the present research, the definition of *risk* is the possibility of financial losses or gains (Verbano & Venturini, 2013). SME risks vary. Belinskaja and Velickiene (2015) provided a multi-faceted classification of SME risk in manufacturing and trading industries and classified relevant SME risk literature up to 2009 by source (internal versus external), nature (pure versus speculative), and project. The intersection of internal financial risk associated with project management was critical yet lacked examination in the current literature (Verbano & Venturini, 2013).

The present research addressed this topic by investigating how to mitigate cognitive bias in the decision-making process to result in better decisions. Improved decision-making in this area may contribute to the literature and provide practical insights that SME decision-makers can use as tools to mitigate financial project risks. SMEs' organizational structures also present risks. In small firms, power is usually centralized (Brouthers, Andriessen, & Nicolaes, 1998). Wyer and Mason (1999) noted that small businesses are potentially disempowering structures due to owner-manager and size-related characteristics that lead to autocratic styles of management and minimal delegation of authority.

Many researchers argued that company size can affect decision rationality (Elbanna & Child, 2007). For example, employees with different opinions often struggle to perform their role. Exiting the business becomes a very real possibility for them (Scase & Goffee, 2015). When leaders delegate decision-making, the relationship between owners and employees changes. Senior managers at SMEs are closer to operational issues on a daily basis (O'Regan, Sims, & Ghobadian, 2005). Their proximity to day-to-day activities and leadership style influence the decision-making behavior of employees. Delegated authority can be *temporary in nature* (Dunning, 2007). The implication is that each decision of a front-line manager is subject to scrutiny and evaluated for quality by the Owner. Such oversight may influence the way individuals make decisions in a SME environment. Owners dominate organizational culture and influence the decision-making of managers (Dunning, 2007). Leadership styles in SMEs typically begin as autocratic before moving to democratic and then to laissez-faire as the owner delegates more and involves others in the decision-making process (Mihai, Schiopoiu, & Mihai, 2017).

SME owners may perceive themselves as using a participatory leadership style (e.g., coaching, selling, and supporting), but followers often perceive leaders as delegating, directing, and telling in addition to coaching and selling (Vidal, Campdesuñer, Rodríguez, & Vivar, 2017). "The owner's vision has been explained by Chell and Tracey (2005) as a proclamation of the opportunities available to those willing to get onboard the owner's journey" (Dunning, 2007, p. 72). In environments in which decision-making is limited, cognitive biases may be identified and addressed on an individual basis. A SME provides such an opportunity due to the smaller number of employees and limited decision makers within the organization. Additionally, an embedded researcher may also have opportunities to observe participants and detect biases through routine personal interactions.

Enterprise Resource Planning Systems

ERP systems are software applications that map the processes and data of an enterprise into a comprehensive structure (Klaus, Rosemann, & Gable, 2000). These information systems support recurring business transactions (e.g., procurement, sales, accounting) and are a source of business intelligence (BI) due to the aggregation of the organization's data via the reporting functionality. ERP systems include packages of preconfigured, popular modules or SMEs can customize it to their specific needs. ERP software can interface with several other types of software. Given the degree of flexibility and ability to have one set of data, the benefits of such a system for decision-making purposes is obvious. Some researchers argued that ERP is best suited for supporting recurring business processes (Klaus et al., 2000). However, the introduction of BI applications expanded ERP systems to organizational use.

Despite the wide array of functionality, manufacturing companies are selective in the modules they implement (Mabert, Soni, & Venkataramanan, 2000). The top five ways (i.e., 87%

of all modules) in which SMEs use ERP systems include: finance/accounting, materials management, order entry, production planning, and purchasing (Mabert, Soni, & Venkataramanan, 2003). Table 1 shows the results of a survey of U.S. manufacturers regarding the modules they implemented and the order of implementation (Mabert, Soni, & Venkataramanan, 2000).

Table 1

ERP Modules Implemented and Implementation Sequence

Sequence	Module	Frequency
1	Financial Accounting	91.50%
2	Materials Management	89.20%
3	Production Planning	88.50%
4	Order Entry	87.70%
5	Purchasing	86.90%
6	Financial Controls	81.50%
7	Distribution/Logistics	75.40%
8	Asset Management	57.70%
9	Quality Management	44.60%
10	Personnel/Human Resources	44.60%
11	Maintenance	40.80%
12	R&D Management	30.80%
13	Other	9.20%

Note. Excerpt from Mabert, Soni, and Venkataramanan's (2000) study of ERP functionality implemented in U.S. manufacturing firms (p. 55).

A similar survey of Swedish firms supported the frequency of implementation of the top five (Olhager & Selldin, 2003). Given the stable popularity of these functionalities, these five modules were the focus of the present exploratory research. The roles ERP plays in organizations include: manipulator, bureaucrat, administrator, consultant, or dismissed (Askenäs & Westelius, 2000).

> If we do nothing, it is probable that the system will move from a good consultant to a competent but unimaginative bureaucrat, or become degraded to an administrator. It is likely to move from a useful bureaucrat to an annoying and overly conservative manipulator. (Askenäs & Westelius, 2000, p. 433)

The present study of ERP use in the SME context may help to further confirm these findings. ERP systems are common in SMEs (Grabski et al., 2011). However, because SMEs are not like LEs, further ERP research is necessary in this unique environment.

A 2012 extended literature review of ERP systems in SMEs noted little in this area of research. Haddara and Zach (2012) identified a total of 77 publications on the topic, mostly adoption, acquisition, and implementation research. Very few publications included ERP use and maintenance. Most researchers in this arena use case studies and surveys. There were only two AR method publications (Haddara & Zach, 2012). To better understand this segment of industry, it was necessary to engage with the subject, introduce a change, and observe results. AR was therefore an ideal methodology for this study.

Despite limited research, some interesting findings emerged regarding SMEs. Chang et al. (2008) developed a life cycle management framework that included recommendations for risk measures and quality confirmation. They recommend organizations routinely revisit the system to ensure that the business evolved (Chang et al., 2008). These recommendations are internal and

the firm remains dependent on the knowledge and skills of the individuals within it, which are often limited (Millers & Sceulovs, 2017). In my professional experience, SME owners often view *not ideal* and *broken* as two distinct classifications due to limited human capital and funds. Chang et al.'s (2008) recommendation is proactive. In contrast, SME decision-makers often focus on shorter horizons and more immediate concerns.

Teittinen, Pellinen, and Jarvenpaa (2013) investigated ERP use in SMEs using case study methodology and found serious challenges that result from inadequate system use. The ERP system under investigation was limited to financial accounting, which presented a challenge for SME owners who may delegate but still desire to retain a watchful eye over the business (Dunning, 2007). Similar findings emerged in research related to Portuguese SMEs that realized benefits of limited management control (Ruivo, Oliveira, & Neto, 2014). SMEs may not be aware of the expanded benefits of ERP or there could be other factors that limit their use. SMEs may fail to take full advantage of ERP due to limitations in resources. Another problem may be a lack of understanding regarding how such a system can help the organization. It is difficult to reconcile why SMEs would expend their limited resources and then not fully exploit ERP systems.

Two studies of uncertainty and ERP had optimistic findings (Koh et al., 2005; Koh et al., 2006). These studies identified causes of late product deliveries, but the system was not able to reduce uncertainty because of a multitude of contributing factors. SMEs are often inconsistent in their maintenance of transactional information that would provide strategic benefit (e.g., order due dates) (Koh et al., 2005). Similarly, Chaabouni and Ben Yahia (2014) found that some firms reported an increased ability to detect problems from a variety of sources and identified ways ERP systems could support almost all phases of the decision-making process. Other firms

reported the system assisted in only select phases of the decision-making process, such as gathering information. These apparent conflicts may be attributable to the module investigated and individual differences (Chaabouni & Ben Yahia, 2014).

Rowe, El Amrani, Bidan, Marciniak, and Geffroy-Maronnat (2005) noted that the ERP improved cross-functionality and helped eliminate silos in SMEs. Their mixed method research highlighted the critical nature of the leader due to the more centralized management in SME environments. However, Rowe et al. (2005) noted that additional research using multiple stakeholders was necessary. An engaged research methodology, such as the present AR, addresses this request.

Maurizio (2017) investigated how SMEs use ERP in logistical and production practices and confirmed the continuing tendency for SMEs to concentrate critical knowledge in a small group of people. However, ERP was a coherent information system and a better solution than unstructured applications, such as spreadsheets. Two studies investigated BI within the SME context. One concluded that BI may lead to better decisions and provide a consistent competitive advantage (Papachristodoulou, Koutsaki, & Kirkos, 2017). Papachristodoulou et al. (2017) examined common time constraints for SME decision-makers and presented BI as tool to provide more precise and current data, reduce analysis efforts, and support risks and chances. Puklavec, Oliveira, and Popovič (2018) proposed remedying issues with data interface between systems by using a BI tool as part of an existing ERP in lieu of a bolt on application that simply uses the ERP data in a different system.

In general, past researchers identified lack of expertise and resources as problems for SMEs using ERPs as noted by Haddara & Zach (2012) in their extended literature review publication. However, this research was in the preliminary investigative stages and

overwhelmingly included surveys, questionnaires, and interviews. Researchers must take a more proactive approach to this issue by conducting experiments and observing their impact in real world settings.

Fisher (2012) concluded, “Decision-makers dealing with an unpredictable environments and uncertainty favor experimentation and iterative learning instead” (as cited in Torkkeli, Salojarvi, Sainio, & Saarenketo, 2015). This is a critical feature of SMEs, particularly in the first few years of creation as grow and attempt to survive. SMEs may welcome the research community as they struggle with sustainability.

Decision-Making Errors and Biases

Researchers of decision-making biases in SMEs focused predominantly on the owner-manager possibly due to the centralized management structure of these organizations (Brouthers, Andriessen, & Nicolaes, 1998; O’Regan, Sims, & Ghobadian, 2005; Ogarca, 2010, Ogarca, 2015). I did not identify any publications that discussed cognitive biases of non-owner SME decision-makers. This presents a significant gap in the literature. Investigating whether cognitive biases, most frequently associated with entrepreneurs, also manifest in non-owner managers could expand the current understanding of decision-making in this unique environment.

Despite the lack of explicit research, there is some evidence that suggests these biases trickle down the organizational hierarchy. Brouthers et al. (1998) stated that the strong personal influence of the founder decreases rationality in these firms and the number of people involved does not alter the rationality of decisions made. In the present study, I speculated that while the quantity of decision-makers may not be a factor, the culture in which decisions are made is a factor. When a directive leader stated their preferred solution early in a discussion, other team members acquiesced to the leader (Gibcus & Esser, 1998). Similarly, Dunning (2007) confirmed

the challenges that salaried manager in the SME environment experience if they fail to conform to the owner's values. Non-owner decision-makers adopt the *go along to get along* strategy. If a bias appeared and the team accepted it, eventually they may become blind to it. I infer it is not the source of the bias that is the contention but the fact that it exists at all within the organization.

Others scholars surmised that biases result from time constraints of the decision-maker (i.e., owner-managers do not have time for a thorough, rational decision-making process) (Busenitz & Barney, 1997). Ogarca (2015) instead concluded SME decision makers were more reactionary and action oriented. One of the key characteristics of small businesses is limited resources, which includes personnel (Welsh & White, 1981; Ojala, 2006; Verbano & Venturini, 2013). Employees in SMEs experience stressors, seek to expedite decisions whenever possible, and may be more susceptible to biases. There are different types of cognitive biases. Optimistic bias and overconfidence are two biases that can influence decision-makers and result in poor decision outcomes. Planning fallacy and representativeness are critical thinking errors that contribute to poor decision-making and can result from these biases (Kruger & Evans, 2004).

Optimistic bias is the tendency of an individual to underestimate or not recognize risks (Kahneman, 2011). Geers and Lassiter (2002) found that overly optimistic entrepreneurs often discount negative real-life information. Kahneman and Lovallo (1993) explained, "A forecast readily becomes a target, which induces loss aversion for performance that does not match expectations, and can also induce satisfying indolence when the target is exceeded" (p. 28). There is little evidence to support that organizations can avoid optimistic bias, except in instances in which problems are recurrent and subjected to statistical quality control (Kahneman & Lovallo, 1993). Because decision-makers struggle to avoid cognitive biases and there are few formal procedures in SMEs to address them, cognitive bias is common in this context.

Moore & Healy (2008) defined overconfidence as, "the excessive certainty regarding the accuracy of one's beliefs, or what we call *overprecision*" (p502). This aligns with the definition of overconfidence (i.e., the positive difference between confidence and accuracy) (Schaefer, Williams, Goodie, & Campbell, 2004). This cognitive bias contributes to the starting *and* failing of SME firms due to higher risk tolerance (Gudmundsson & Lechner, 2013). Overconfidence bias can exist to such as extent that a decision-makers' accuracy is essentially equivalent to a random coin toss because they believe they will be right despite often being wrong about the outcome of business situations (Moore & Healy, 2008). In SMEs, decision-makers often display overconfidence bias due to the focus on firm survival and limited resources. They adopt a *no news is good news* approach. Unfortunately, other team members face the same resource restrictions. Ultimately, managers and owners only revisit the most disastrous decisions or deviations from expectations.

Prior researchers tested a variety of debiasing techniques with varied results. The most common techniques to minimize overconfidence include considering alternatives, training, and providing feedback (Russo & Schoemaker, 1992; Kahneman, 2011; Ferretti, 2016; Simon & Kim, 2017). Overconfidence contributes to another decision-making error, planning fallacy. Kahneman and Tversky (1979) identified this error as an underestimation of how long a task will take despite having access to similar cases. "With the planning fallacy, the future continues to look rosier than the past, even as the future becomes the past" (Buehler et al., 2010, p. 3). Sample (2015) described this aspect of knowing yet ignoring prior experience as, "more self-deception and delusional rather than intentionally deceptive" (p. 57). This indicates it may operate subconsciously, which further supports research findings that making individuals aware of the planning fallacy cannot eliminate it (Kahneman & Lovell, 1993).

Beuhler et al. (2010) expanded the planning fallacy model to include other factors such as temporal distance, first- versus third-person imagery, actor versus observer status, incentives, group versus individual, and social power. The expanded included several characteristics of small business environments. SMEs' struggle for survival results in a predominantly plan-based viewpoint that discounts past negative experiences as *growing pains*. SMEs are future-oriented and work to progress with their current resources. The most common solutions are to consider obstacles, take an external perspective, and break down a project into smaller steps (Buehler, Griffin, & Peetz, 2010). However, these recommendations may harm SMEs. When decision-makers are also the doers, it can be difficult to adopt an external perspective. The experimental nature of small businesses does not lend itself to consideration of what could go wrong, only how to achieve the present goal. Breaking down a project is also challenging if significant processes are involved and not easily recalled. Small business owners tend to be less formal and may not have all the steps of an activity discretely identified to facilitate the break down process (Buehler et al., 2010).

Representativeness is a decision-making error in which people choose to make an easier decisions than the one initially facing them. For example, Kahneman and Tversky (1972) identified this phenomenon as an instance in which a person ignores the statistical probability of occurrence and instead judges the likelihood based on similar characteristic to other information, regardless of its quality. Kahneman (2011) noted that even when given worthless information, the human brain automatically processes it as if it is true. It is difficult to discern whether this is due to representativeness (classification) or availability (recall) (Braga, Ferreira & Sherman, 2018). Questions remained if this behavior is because of our interest in immediately classifying something as true to get to a solution as quickly as possible or simply because we forget to

consider the likelihood of our classification being accurate based on statistical analysis. Braga et al. (2018) found that representativeness presented most often. However, under time constraints, the availability heuristic was more frequent. Essentially, if people do not have time to think and compare data to expectations, then individuals will select the first option that comes to mind (Braga, Ferreira & Sherman, 2018).

Based on my experience in the SME environment, people make decisions quickly but still typically require some amount justification. Because feedback can be limited, unrealistic expectations and standards are common. Use of phrases such *it should take this long* provide evidence of representativeness in which a person compares a current estimate to what is known about organizational performance, even though there is little evidence to support the validity of the standard. Syntheses of the decision-making process and related bias exist in the literature (Hogarth & Makridakis, 1981). They developed a conceptual model of judgement that is a framework for the decision-making process and provided a concise list of biases according to "acquisition of information, processing of information, output, and feedback" (Hogarth & Makridakis, 1981, p. 117).

Summary

The relationship between SMEs, ERP, and bias is not yet well understood. Most researchers' methodological choices suggested that their investigations of ERP and bias were in the exploratory stage, seeking to explain rather than change how SMEs operate. The present research also contains an exploratory component. However, the intent was to take a step forward by means of a secondary prescriptive research question that introduced new artifacts into the organization. I then evaluated their effect. This research addressed SMEs' financial risk in a

project management context via improved decision-making due to bias mitigation. An ERP system and its output may be effective mitigation tools for SMEs.

CHAPTER THREE:

RESEARCH METHODOLOGY AND DESIGN

This chapter discusses the research method I used in this study. I describe the research design and the selection justification, data collection, and procedures. The chapter also includes a description of the methods of data analysis. Finally, I discuss ethical considerations.

Research Method

The motivation for this research was to solve the real-world problem of mitigating bias in the pricing decisions at one SME organization using an ERP system and its outputs. As an employee of the organization, I became an embedded researcher in the environment with ample access to data. Based on personal experiences, the SME was a learning organization and incremental insights and evolution drove change rather than one-time comprehensive solutions. Routine contact and established relationships with decision-makers at the organization permitted collaboration. Therefore, the best method for this research was action design research (ADR).

ADR is a structured method of addressing real world problems that includes a reiterative process resulting in experimental learning; there is no barrier between the researcher and participant (Avison, Lau, & Myers, 1999). Other researchers used or proposed use of this method for research on SMEs, acknowledging it would provide valuable hands-on experience (Haddara & Zach, 2012). I evaluated other methods and rejected as not suitable for this research. Both quantitative and mixed methods approaches were inappropriate due to the limited sample size, lack of an initial hypothesis, and the absence of statistical data analysis (Wiśniewska, 2011). Qualitative methods were not a good match due to the embedded nature of the researcher.

Furthermore, qualitative researcher is inductive exploration with no pre-existing expectations; I suspected cognitive biases may contribute to the phenomenon. The intervening characteristic, facilitating change and improvement, also differentiate this research from a case study methodology (Simonsen, 2009).

ADR is ideal for this research for several reasons. ADR researchers address real-world problems, collaborate with key stakeholders, participate in the study environment, and generate knowledgeable learning outcomes (Haj-Bolouri, Purao, Rossi, & Bernhardsson, 2017). ADR allows for the use of small sample sizes. The researcher is a participant working alongside key stakeholders to solve problems. Such emic positioning is a key tenet of ADR, which provides the researcher with more flexibility and does rely on statistics. This permits a greater variety of data collection tools that the researcher may apply sequentially and concurrently (Haj-Bolouri et al., 2017).

Within ADR, a recent more expanded methodology exists. Elaborated action design research (eADR) has four distinct cycles: diagnosis, design, implementation, and evolution; this method of AR includes problem formulation, artifact creation, evaluation, reflection, and learning within each cycle (Mullarkey & Hevner, 2018). Selection of this method permitted a comprehensive, yet flexible, investigation and the creation, evaluation, and enhancement of artifacts. Figure 1 depicts the cycles and activities that occur within each cycle of eADR.

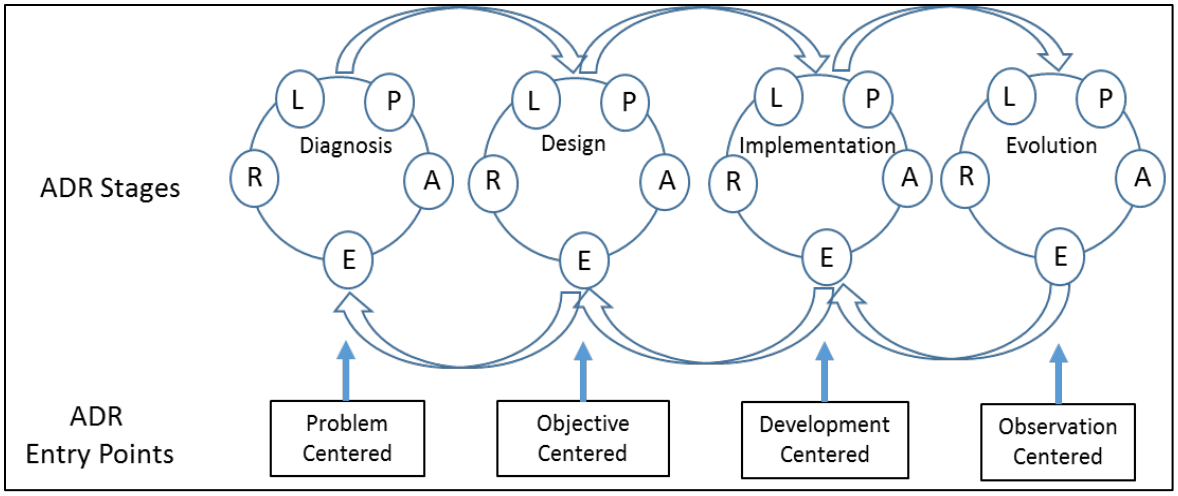


Figure 1. Elaborated action design research model. Adapted from Mullarkey and Hevner (2018).

Scholars successfully used ADR but I completed a careful review of the weaknesses of this methodology to mitigate them during this research project. Concerns included the influence the researcher may have, the Hawthorne effect, and the validity of the research itself. "Action research enables you, as a researcher, to be a 'part of the game'" rather than merely an observer of information system practices (Simonsen, 2009, p. 121). Such participation means that researchers must be aware of any personal biases and strive to minimize them. I mitigate this concern by identifying it beforehand and implementing methods to limit it (e.g., avoiding leading questions, sharing finding with participants, seeking feedback, and data triangulation).

The Hawthorne effect is the modification of a subject's behavior due to an awareness of observation (Gottfredson, 1996). I established positive rapport with participants after participating in several successful cross-functional initiatives as an employee. This limited the risk of triggering *an outsider looking in* response. To further mitigate this concern, I triangulated data.

A final concern related to ADR is its validity. “The research outputs must have a broader interest and theoretical significance if the work is to be truly differentiated from, as many critics characterize it, consulting” (Street & Meister, 2004, p. 496). Prior to beginning this project, I ensured that the dual objectives of scholarly and practical contributions were clear. The scholarly objective was to expand the body of knowledge on managing decision-making biases in SMEs. The practical contribution was to assist my employer’s organization in improving pricing decisions using their existing ERP system.

Research Design

The subject of this research was the U.S. segment of a SME that resulted from an asset purchase completed in the fourth quarter of 2015. The CEO of the SME has extensive experience improving the profitability of failing companies. The employee base of this SME is varied with some new employees and others who worked with the prior company for more than ten years. The organization was poised for sale prior to the acquisition. As such, it experienced an increased level of key personnel departures and market share loss. The culture of the organization was very tactical in nature. Decision-making originated from a responsive stance, addressing concerns as they arose rather than intentionally solving problems to meet future needs.

I proposed a project idea to the CEO during the spring of 2017. The project plan developed over the next several months and the SME initiated it in early 2018. Generally, the research design followed the systematic outline of eADR steps (see Figure 1). Potential participants included all employees of the organization. I examined the roles of six decision-makers with varying levels of authority. To ensure a thorough understanding of the issue, I adopted a problem-centric entry point into this eADR research, seeking first to understand

current use of the ERP system and outputs in the decision making processes at this SME. I conducted and recorded exploratory, semi-structured interviews with each participant. This data informed a list of potential factors that currently inhibiting reliance on the ERP and its outputs during decision-makings processes. Limited validity checks on thematic research coding of interviews occurred via peer review. This feedback was used to identify and add additional themes and recode interview data to better clarify analysis. I then completed follow-up interviews in which each participant to explore all the causes they identified and determine whether and to what extent they affected decision-making. Participants provided examples and ranked the importance of all previously identified concerns. The second cycle of interviews reduced the scope of the research to the most critical concerns that participants identified.

During the design phase, I used brainstorming to develop potential solutions and then down-selected the initial solutions based on available resources and other feasibility factors specific to the organization. I further segmented the solutions by concern, type, and level of participant involvement. I evaluated potentially positive impacts on decision-maker(s) and pricing decisions (e.g., some solutions might assist all participants while others helped only one). I evaluated the solutions by time requirement and developed a project plan to address the most frequent, important, and easily solved issues. I created multiple artifacts via an independent design and implementation phase that generally consisted of at least two cycles for design and one for implementation. For example, I collected interim feedback during meetings and through email and conversations on each artifact from stakeholders and used that data for further refinement. This stakeholder approval allowed the artifact to progress to implementation at which point I solicited initial deployment feedback. If necessary, the artifact would return to the design phase for modifications, approvals, and reimplementation. The fluidity between design

and implementation discontinued when the stakeholder(s) reported satisfaction with the artifact and no additional modifications were identified.

Data Analysis

After implementing all artifacts and achieving a steady state of stakeholder satisfaction, I conducted an analysis of summative effects on the pricing decision. This included follow-up interviews with participants to obtain their perspectives on the artifacts' impact on their decision-making. I compared price estimate elements, labor, and material to actual data before and after introduction of the artifacts to identify changes in the level of accuracy of these categories.

Ethical Considerations

Human subjects participated in this research, but IRB approval was not necessary. All interview participants are business professionals and I limited the inquiry to discussions regarding their professional experience and opinions. Such conversations and resulting actions may have occurred organically due to International Organization for Standardization (ISO) 2015:9001 standards that required companies to consider and implement opportunities for improvement within their organization.

CHAPTER FOUR:

EADR DIAGNOSIS STAGE REPORTING

This chapter includes a detailed explanation of the diagnosis phase and the results of this eADR research. It also includes a more detailed description of the data collection process for each distinct activity. This chapter concludes with a discussion of the findings from this portion of the research, which became inputs into the subsequent design cycle as I will discuss in the next chapter.

The gross margin performance on projects at the SME in this study was not meeting expectations in 2015. The estimates for how much a product should cost to produce and how long it would take to make were consistently too optimistic, resulting in overruns. This stunted financial growth and sparked speculation that the manufacturing team, rather than the process, needed replacing. I adopted a problem-centric approach to this eADR research using two diagnosis stage cycles to gain understanding of the current SME environment before moving into the design stage.

Cycle One

Problem formation. I conducted exploratory interviews to gain insight into when and how employees use ERP information in decision-making. This consisted of interviews with six full-time employees whose roles closely aligned with the most common ERP functionality in U.S. manufacturing companies. The average tenure of participants in their current position was less than two years but all held prior jobs of a similar nature in other organizations. As an

incentive to participate, I informed participants that their data would inform future system enhancement and configuration changes related to the current ERP system.

Each interviewed occurred at their work place, had a semi-structured format, and lasted between 12 and 58 minutes. The complete interview guide appears in Appendix A. I tape-recorded all six initial interviews. Each interview began with a brief description of the study and assurance that all data would be confidential. Participants stated their title, role, and years of experience. I then asked each participant to consider three scenarios, provide an example, and reflect on their experience as it related to that example.

- Scenario 1: Describe a decision that you make that uses information from the ERP system.
- Scenario 2: Describe a decision that you make that does not use information from the ERP system.
- Scenario 3: Describe a decision that you make where ERP information is available but is not used.

The interview concluded with an opportunity for the individual to express their opinion on ERP usage and provide recommendations.

Artifact creation. I collected data using a recorder and converted the recordings into transcripts. A professional service transcribed the two longest interviews. I listened to each interview, including the professionally transcribed ones, at least twice to ensure I captured all relevant data (i.e., all data relevant to the questions and focus of this research).

Evaluation. I used qualitative data analysis software, QDA Miner Lite, to code and analyze the interview content. See Appendix B for initial coding scheme and updates post-interviews. I developed the primary coding scheme based on descriptive concept and process

coding guidelines suitable for exploratory research (Saldaña, 2013). Additions to the coding scheme reflected analysis of the data. Secondary coding occurred by categorizing codes, identifying relationships between codes, and generating themes. This coding synthesized the data so that I could develop areas of focus for the design stage. Efforts in this stage resulted in several factors that participants cited as reasons for limited use of the ERP and its outputs in the decision-making process.

Reflection and learning. While informative, initial interview results were not actionable. It was unclear how pervasive the concerns were. Did they impact one or many decision-makers in the organization? It was also unknown how decision-makers compensated for them. Therefore, a second diagnosis cycle was necessary to acquire additional information for the design cycle.

Cycle Two

Problem formulation. Cycle two of the diagnosis phase involved investigating the most frequently coded concerns. The problem during this cycle was to determine how many individuals raised a concern during cycle one and how they ranked it to better understand compensation techniques. The primary difference during this cycle is that the concerns were given to participants and limited to those previously identified during cycle one.

Artifact creation. I presented each interview participant with five primary concerns that emerged from the initial interviews and asked them to consider whether these concerns influenced their non-use of the ERP. If participants shared an affirmative response, I provided an example to verify the response and asked interviewees to discuss how they currently compensate for the concern. Participants ranked the concerns by perceived importance to them. I did not record these interviews due to concise nature of questions and data collected, but took notes

during and after each session. The interviewees reviewed and approved their documented response, compensation technique, and importance ranking before completing the interview session.

Evaluation. I consolidated all responses and shared them with participants. The five concerns ranked by importance were:

1. missing/incomplete information;
2. data accuracy;
3. data consistency;
4. inconvenient access; and
5. self-reliance.

No participant reported all areas and the most common frequency was three concerns. Of the five, *incomplete/missing information* and *self-reliance* were the most important factors participants reported as impacting use of the ERP. Participants agreed that I appropriate ranked these issues influencing use of the system upon review of the findings.

Summary. Despite the variety of tasks, roles, individuals, and decision-making characteristics, all participants expressed concerns that limited their use of the ERP. These concerns fell into three general themes: data, human interfaces, and cognitive bias. Interview excerpts supported the validity of these themes.

The Data

All interviewees agreed that incomplete and/or missing information negatively affected their use of the ERP system. One participant stated, “Sometimes it says on the screen for example, freight forward company. That doesn’t mean anything except that it is an external. In the PO it mentions exactly what company it is” (Accountant LT 30.01.2018). Another explained,

> Yes, sometimes I have to go to him to get pictures of the parts because the system might say we have 10 of them but it doesn't give me a location. I need a picture of something so that I know what to look for. (Inventory Clerk NG 31.01.2018)

As one participant noted, "We don't have the set up yet. I don't think we are thinking in those details yet. I think the perception is we have a job and we just do it and it takes as long as it does" (Owner DS 02.02.2018).

Two individuals reported that data accuracy influenced the level of reliance on ERP information during the decision-making process. One explained, "System says you need four, system says you have four and then you don't necessarily trust the system for that four" (Supply Chain Manager KR 06.02.2018). Another participant stated, "It is just finally starting to get on track where everything is [the counts] accurate, so you can't really go based on what the system says" (Inventory Clerk NG 31.01.2018). Consistent with prior research, the accuracy of information directly influences how useful the information is to employees (Haug, Stentoft Arlbjørn, Zachariassen, & Schlichter, 2013).

Despite failing to correct errors, no interviewees reported a complete disregard for the ERP information based on past inaccuracies. This suggests that employees are willing to use the system as a primary source of data, and default to alternate information sources only when they deem necessary. Their responses were surprising. Each interviewee reported alternate information validation methods (e.g., visual inspection) and proceeded to the next step in their decision-making process rather than taking measures to correct the information in the ERP system. This is indicative of the task-driven nature of SMEs.

Only one interviewee reported that the consistency of data was a limiting factor.

"Since the part numbers have not been assigned or maintained consistently, I want to validate an item if we haven't made it since I started doing this role" (Estimator CM 03.04.2018). Due to limited resources and dual roles, employees attempt to streamline activities when possible. Due to having only a single decision-maker, tactical decision-making tendencies, and lack of formal processes, *standing data* can become unreliable or have multiple meanings to employees.

Human interfaces. One interviewee reported that accessibility to the system was a limitation. Other participants' roles were more sedentary, which may be why this did not resonate as a contributing factor for them.

> With as much as I'm not in my office, it is hard for me to use the system for that [checking the status of a job]…double checking the job? Sometimes it's easier to look at the traveler on the floor. (Operations Manager JR 02.02.2018)

This statement reinforced prior research findings; when production workers are too occupied with their tasks and do not understand the role of their inputs for the system as a whole, constant problems in systems maintenance are inevitable (Teittinen et al., 2013).

Participants identified missing data as a concern, but in many cases the data was actually present. Either the decision-maker was unaware it existed, uncertain how to obtain it, or needed multiple elements to join in a meaningful manner. Therefore, missing and incomplete information could also be classified as human interfaces.

Cognitive bias. Four of the six interviewees reported that the ERP was not necessary for some decisions. Employees reported that they *just knew* information and felt comfortable moving forward with their plan of action. One employee shared,

> So if you're the only buyer then you're the one who bought that part that he's looking to have replaced. So yes, you know exactly where that part came from…It's something

> called the warm fuzzies and not the warm fuzzies [PO placement decisions]. (Supply Chain Manager KR 06.02.2018)

Another participant explained, "I call it emotional type decision-making where it's historical information with customer relationship strategic pricing previously" (Estimator CM 30.01.2018). Similarly, an operations manager stated,

> I can tell just by the cell the raw material is in and what it looks like, the status of a job and when it is ready to move on to the next operation…Scheduling is easier for me to keep it on paper or just in my head. (Operations Manager JR 10.04.2018)

The owner summarized it concisely by stating, "We are very tactical. It happens to everybody. When you are starting, you're just trying to survive day to day" (Owner DS 02.02.2018).

After multiple diagnosis cycles, I was confident the participants adequately identified their concerns. Ranking permitted the team to focus on the most important results. I obtained evidence confirming cognitive bias in the current decision-making process at this organization. Table 2 lists the themes that arose from these cycles.

Table 2

Themes of Decision-Makers' ERP Concerns

Data	Human Interfaces	Cognitive Bias and Errors
Missing/Incomplete Information	Unknown Functionality	Overconfidence Bias
Data Accuracy	Incomplete Information Sets	Optimistic Bias
		Planning Fallacy
		Representativeness

This chapter described the research actions associated with the diagnosis stage of this eADR project. Using exploratory research methods and multiple cycles, I identified how decision-makers currently use the ERP system and its output in their pricing decision making. The results were that decision makers' concerns could be classified into three themes described as data, human interfaces and cognitive bias and errors. These insights became inputs into the design cycle of this research.

CHAPTER FIVE:

DESIGN, IMPLEMENTATION, AND EVALUATION CYCLE

This chapter includes details of the design, implementation, and evaluation eADR stages of this research. I compared the ERP concerns that participants identified to the existing pricing practices of the organization. Shifting the organization's view from a customer-centric pricing model to a product-centric pricing model could mitigate bias and produce more realistic estimates as decision-makers focused on the elements of the product rather than potential response to the overall price. Providing more feedback at the elemental cost category level was critical to helping decision-makers understand their accuracy level and adjust when necessary.

Before this eADR, the estimating process began by trying to understand the customer and their price point. Employees compared new customers to the existing customer base and classified them as similar based on industry, price sensitivity, or requirements. They developed an estimate for expected labor hours and material costs, but often obtained the estimate by pulling cost data from similar past customers. Once complete, they distributed the estimate, incorporated feedback, and engaged in further price reductions to secure the order. Customers drove price breaks in the organization rather than the complexity of the products or materials.

To better standardize pricing, it was necessary to shift the organization's focus to a product perspective to more reasonably align the price of the product with the actual cost to produce. Decision-makers would have a more global view of what a product costs to build rather than what a customer would expect to pay. Price-to-win decisions could be more strategic (e.g., discounts to enter a new market or gain market share rather than to secure a single order). If

more individuals were aware of the price-to-win strategy, they could take additional actions to reduce costs and cover discounts.

To facilitate this, I developed artifacts based on components of the bottoms-up pricing model for labor and material. Artifacts provided historical data in a format that supported decision-makers' search for product information by providing production level detail. With the new artifacts, employee policies and procedures focused on data accuracy instead of the customer. Each design made the product the primary focus rather than who would buy the product. Figure 2 represents estimating methods before this research on the left and after the eADR project on the right for a single product line. The center portion shows interventions and their expected area of influence on the pricing equation. Each artifact provided feedback about costs of production. I designed each artifact independently; so, the research progressed in a horizontal manner after analysis, each step informed by the previous.

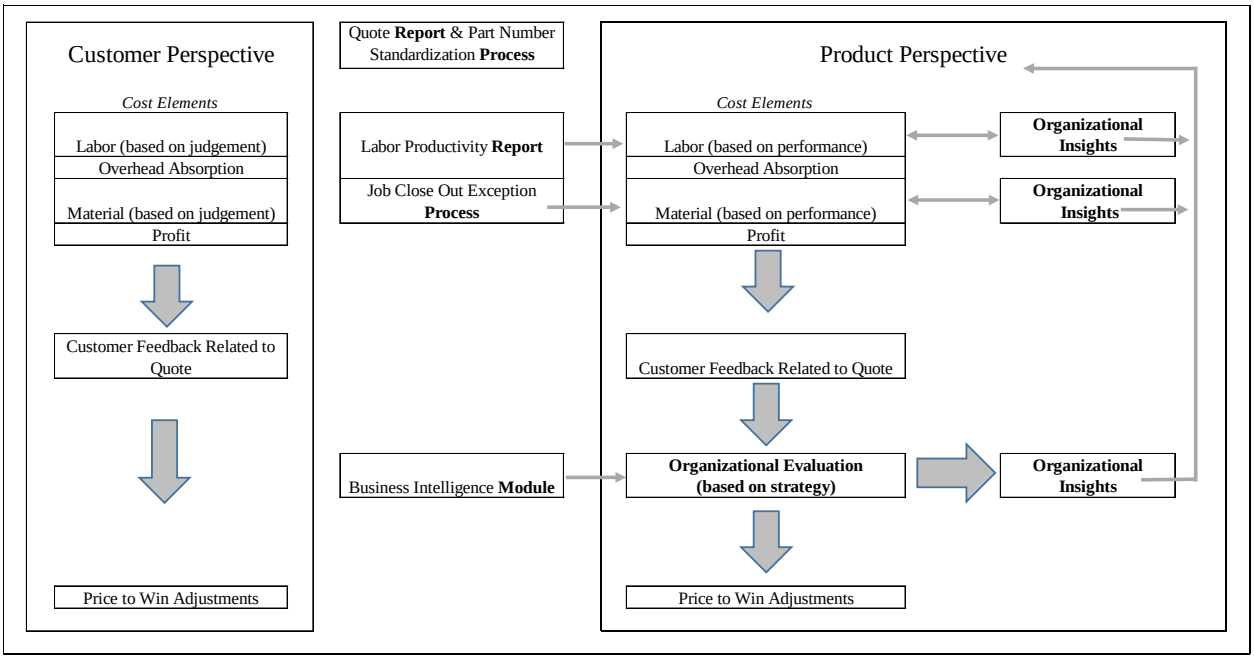


Figure 2. Intervention model to shift pricing viewpoint to product focus.

The design phase reflected the philosophy that it is easier to edit than create based on the work of Guillaume Ferrero (1894) who proposed that humans operate on the principle of least effort. Prior experience with this team proved that giving them something tangible, such as an example report or process document, to begin with propelled them forward in projects. They preferred solutions that addressed multiple areas. Table 3 reflects this approach, providing researcher-identified solutions based on information from the diagnosis stage along with the artifacts' intended mitigation areas of influence. The artifacts that I developed during the design stage took a variety of forms and resulted in the introduction of two new reports (e.g., a new business policy and a new business process). The process of evaluation, reflection, and learning was different for each artifact. Therefore, the table categorizes these components in the design stage by artifact.

Table 3

Artifacts and Anticipated Impact on Decision-Making

	Overconfidence Bias	Optimistic Bias	Planning Fallacy	Representativeness
Quote Report	X	X		X
Training	X	X	X	
Labor Productivity Report	X	X	X	X
BI Module	X	X		X
Cycle Count Process	X			
Part Standardization Policy	X		X	X
Job Close-Out Process	X			

Note. Table of artifacts developed and their anticipated influences on decision making biases and errors. An X indicates the artifact is intended to influence the specific bias and/or error listed by column.

Each artifact design cycle began by providing users with a conceptual design and a description of the objective of the effort. The team evaluated, brainstormed, and provided feedback during group meetings and one-on-one interactions, depending on the artifact and number of stakeholders. I used the recommendations and feedback to modify the artifact until participants deemed it acceptable for use. This chapter includes discussion of each of the artifacts and concludes with evaluations and reflections on their implementation.

Quote Report

The estimating team did not have an efficient technique to survey historical quote data while ensuring completeness of all relevant records. Initially, this was due to a knowledge gap (i.e., the estimating team was not aware of a report). After training, the estimating team proposed enhancements that could increase the utility of the report. Using the evolution entry stage, I worked with report writers to rewrite this report in a different computer language that facilitate dynamic filtering. By doing so, the end users gained the capability to search by customer or part number using wild card functionality. The intent was to allow employees to analyze larger volumes of data; therefore, the report exports to a spreadsheet program. See Figure 3 for an example of the report data.

fquotedate	fquoteno	fcompany	fsalespn	fstatus	fenumber	fpartno	festqty	funetprice	fdexpired	fordtime	fordpotent
MM/DD/YY	111111	ABC Company	XX	Ordered	XXX	1111.1111.1111	1	3000	4/1/2018		
MM/DD/YY	222222	XYZ Company	XX	Cancelled	XXX	1111.2111.1111	1	3500	4/1/2018		
MM/DD/YY	333333	123 Company	XX	Cancelled	XXX	1111.3111.1111	1	4000	4/10/2018		

Figure 3. Quote report in spreadsheet format.

The anticipated results were that historical price data by product was easier to compile and variations were more visible during future price setting decisions as others gained insights into the range of prices the organization offered in the past for identical products.

Training

Maurizio (2017) found that SMEs' system knowledge is often concentrated in a small number of individuals. Providing decision-makers with additional training would be beneficial. One-on-one sessions with each participant addressed their specific questions. For example, one participant mentioned that access to source documents would be helpful. I then conducted a training session to show the estimating team how to attach documents to a sales order record. The participant responsible for billing learned to access these documents through the system.

As the SME implemented new artifacts, employees completed training prior to use. I checked in frequently after implementation to gain participant perspectives and answer any questions. Participants felt comfortable asking for help and training request were given high priority. To encourage continued learning, participants learned to access the ERP system help menu, which included step-by-step instructions and user manuals for all ERP modules.

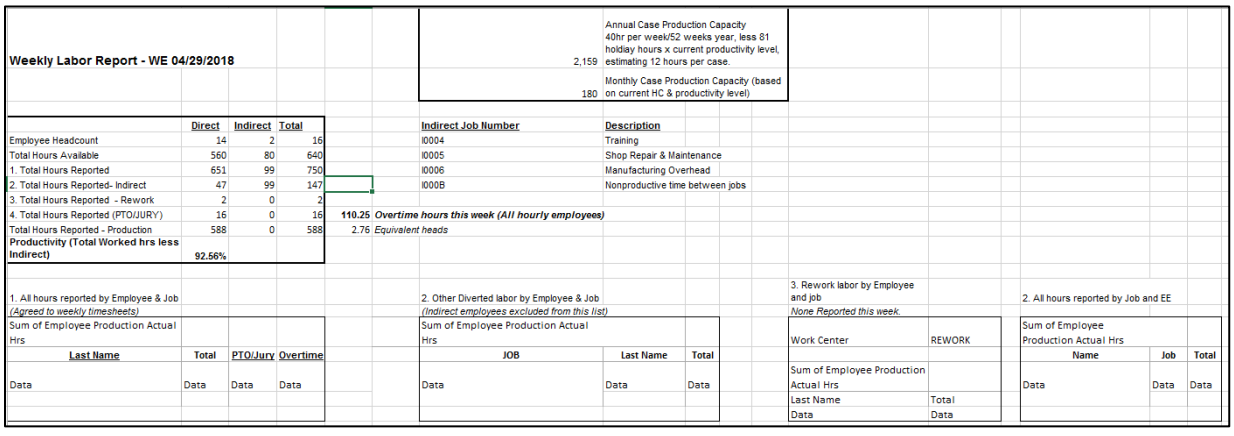
Labor Productivity Report

My past experience demonstrated that the organization was not yet skilled at estimating the amount of time required to produce products due to changes in labor resources, tools, techniques, and materials. Direct labor estimates were consistently optimistic, resulting in cost overruns and conclusions that the manufacturing team work at an optimal pace. The goal of the labor productivity report artifact was to reduce the impact of optimistic bias. Čuláková, Kurtus, Uhlířová, & Jirásek, (2018) recommended a structured objective decision-making process to

inform how employees compile labor estimates within the quote. Previous estimates at the SME in this study reflected a *how long do you think* approach by operations personnel.

Pulford and Coleman (1997) concluded that feedback is important for regulating overconfidence. The operations team did not have a way of obtaining real-time data regarding hours spent producing products. Furthermore, Russo and Schoemaker (1992) recommended accelerated feedback. The state of reporting at the SME was lacking in both areas. There was a weekly review of timesheets, but the data appeared for each employee and made it difficult to determine total hours spent on a job or whether the workforce was efficient overall.

This intervention provided insight into actual labor performance to estimate labor constraints, stress the importance of each product contributing to gross margins, and provide a data validation mechanism to improve the accuracy of job costs. The initial report went through multiple design cycles that added elements (e.g., a calculation of equivalents for overtime dollars) and modified pivot tables. Figure 4 depicts the final format of the report that the SME distributed weekly to operations and senior leadership.



Weekly Labor Report - WE 04/29/2018

2,159 Annual Case Production Capacity 40hr per week/52 weeks year, less 81 holiday hours x current productivity level, estimating 12 hours per case.

180 Monthly Case Production Capacity (based on current HC & productivity level)

	Direct	Indirect	Total
Employee Headcount	14	2	16
Total Hours Available	560	80	640
1. Total Hours Reported	651	99	750
2. Total Hours Reported- Indirect	47	99	147
3. Total Hours Reported - Rework	2	0	2
4. Total Hours Reported (PTO/JURY)	16	0	16
Total Hours Reported - Production	588	0	588
Productivity (Total Worked hrs less Indirect)	**92.56%**		

110.25 ***Overtime hours this week (All hourly employees)***

2.76 *Equivalent heads*

Indirect Job Number	Description
I0004	Training
I0005	Shop Repair & Maintenance
I0006	Manufacturing Overhead
I000B	Nonproductive time between jobs

1. All hours reported by Employee & Job
(Agreed to weekly timesheets)

Sum of Employee Production Actual Hrs

Last Name	Total	PTO/Jury	Overtime
Data	Data	Data	Data

2. Other Diverted labor by Employee & Job
(Indirect employees excluded from this list)

Sum of Employee Production Actual Hrs

JOB	Last Name	Total
Data	Data	Data

3. Rework labor by Employee and job
None Reported this week.

Work Center	REWORK
Sum of Employee Production Actual Hrs	
Last Name	Total
Data	Data

2. All hours reported by Job and EE

Sum of Employee Production Actual Hrs

Name	Job	Total
Data	Data	Data

Figure 4. Labor report format image from spreadsheet.

Fischoff (1981) concluded that training and judgement aids reduce hindsight bias. The metric of direct labor productivity informed the extent to which direct labor employees were not working on customer jobs. The report feature displayed what employees were working on, which helped leaders identify impediments rather than attributing it to a slow overall pace. The report quantified how much time could potentially be gained by clarifying and streamlining job elements. The SME quickly adopted metric as the baseline for evaluating future improvements. Whether this report was successful at reducing the optimistic bias of labor estimates will be a point of discussion later in this chapter.

Business Intelligence Module Training and Deployment

Due to limited time and resources, reflection on past decision quality was often minimal at the SME. Multiple interviewees reported data-overload associated with the ERP. The ERP contained an Executive Information System (EIS) module that was unused by most decision-makers due to lack of training. Participants were either unaware of the module or unsure how to use it. Imre (2016) concluded that SME organizations have a short-term survival focus. Funding and time constraints limit efforts to increase system usefulness rather than simply moving to a new system. Beijsterveld and Groenendaal (2016) recommended that work-arounds are only a good solution when the functionality is necessary but customization is not feasible. Puklavec et. al. (2018) recommended a BI model that is a part of the ERP rather than a third-party solution. The SME in this study's ERP system included a BI module that was ready for use. Therefore, the best option was to revisit the system capabilities before moving to an alternate solution for reviews of past decisions.

A detailed training session and a future reference user manual included the most helpful aspects of the module as they related to sales activities. This training was available to the owner,

estimating team, and sales personnel in the United States and Switzerland. One of the primary benefits of the BI module was that it allowed individuals to view profit margin results on a product level basis. Individuals who were not typically part of the estimating process, could gain insight and learn the cost to produce on a product level basis. This transitioned them away from a customer price setting strategy by providing justification for price quotes. How the prices developed was no longer a mystery for the organization.

Cycle Count Process

A cycle count process existed before this study but the SME discontinued it when the full time position was eliminated as part of a temporary cost reduction strategy. Participants mentioned data accuracy as an inhibitor to ERP data reliance, it was necessary to reinstitute the cycle count process. The team learned about the results of the cycle count process. Prior to posting transactions resulting in changes to the quantities on hand, the proposed adjustments were reviewed by the Controller and discussions conducted with inventory personnel. When a significant variance presented, departmental leaders used it as a method to identify potential problems and conduct subsequent root cause analyses. For example, in one instance, the system reflected quantities of a high dollar component that inventory personnel were unable to locate and marked as zero. Due to the significant variance, they conducted an additional root cause analysis and investigation. After discussion with other team members, they found that it was an example of tribal knowledge. Unmarked material was stored but went unused since purchase. To resolve this, the employees marked the material and demonstrated the importance of inventory control to the team.

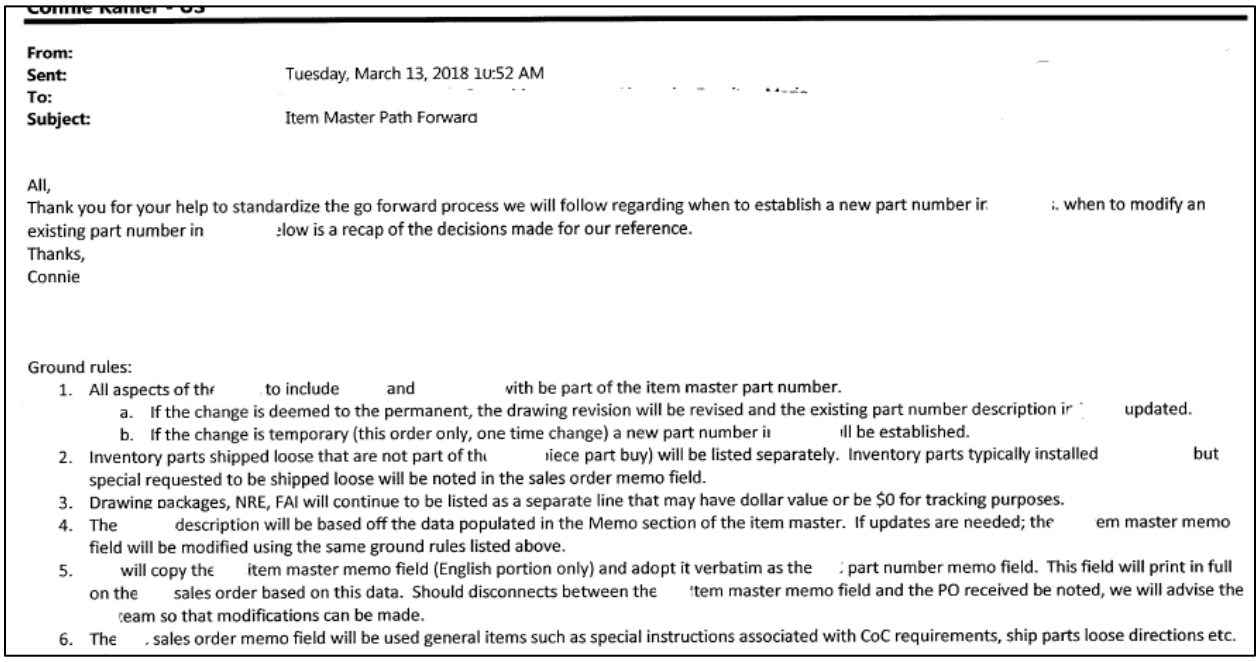
Part Standardization Policy

A common theme during interviews was the inconsistent scope of customer part numbers. Although smart numbering was evident, lack of control over when a part number specification changed and what constituted the need for a new part number made comparisons of historical purchases of similar items at the commodity level a challenge for the organization. As a result, the SME routinely reviewed a small amount of historical data. The sales team used this minimal data to develop price proposals. The lack of an efficient way to analyze data resulted in the sales team's focus on *closing the deal* by influencing other decision-makers to go along with their price point recommendations.

Representativeness (i.e., the assumption that a small population is representative of the larger population) was present. Kahneman (2011) concluded, "we pay more attention to the content of messages than to the information about their reliability…simpler and more coherent than the data justify" (p. 118). Ultimately, the SME needed a solution that would not negatively reflect on the sales team's conclusions while increasing the usefulness of the ERP system. The solution was two-fold. First, standardize what the *customer part* represented to all decision-makers. Second, find an efficient way to produce larger samples of historical quote information and share them with all pricing decision-makers.

The goal of this artifact, at the organizational level, was to institute *ground rules* for customer part item master standardization. To do so, a team comprised of engineering, estimating, sales, and planning decision-makers formed. They isolated characteristics of the product that could change and established thresholds for when a new part number was necessary. The initial discussion occurred in late February and a review of the proposed practice occurred in mid-March 2018. Figure 5 is an email example of the communication of the guidelines. The

procedure was finalized on March 13, 2018 and communicated throughout the organization via email.



From:
Sent: Tuesday, March 13, 2018 10:52 AM
To:
Subject: Item Master Path Forward

All,
Thank you for your help to standardize the go forward process we will follow regarding when to establish a new part number ir ; when to modify an existing part number in low is a recap of the decisions made for our reference.
Thanks,
Connie

Ground rules:

1. All aspects of th to include and with be part of the item master part number.
   a. If the change is deemed to the permanent, the drawing revision will be revised and the existing part number description ir updated.
   b. If the change is temporary (this order only, one time change) a new part number i ll be established.
2. Inventory parts shipped loose that are not part of th iece part buy) will be listed separately. Inventory parts typically installed but special requested to be shipped loose will be noted in the sales order memo field.
3. Drawing packages, NRE, FAI will continue to be listed as a separate line that may have dollar value or be $0 for tracking purposes.
4. The description will be based off the data populated in the Memo section of the item master. If updates are needed; the em master memo field will be modified using the same ground rules listed above.
5. will copy the item master memo field (English portion only) and adopt it verbatim as the part number memo field. This field will print in full on the sales order based on this data. Should disconnects between the tem master memo field and the PO received be noted, we will advise the eam so that modifications can be made.
6. The . sales order memo field will be used general items such as special instructions associated with CoC requirements, ship parts loose directions etc.

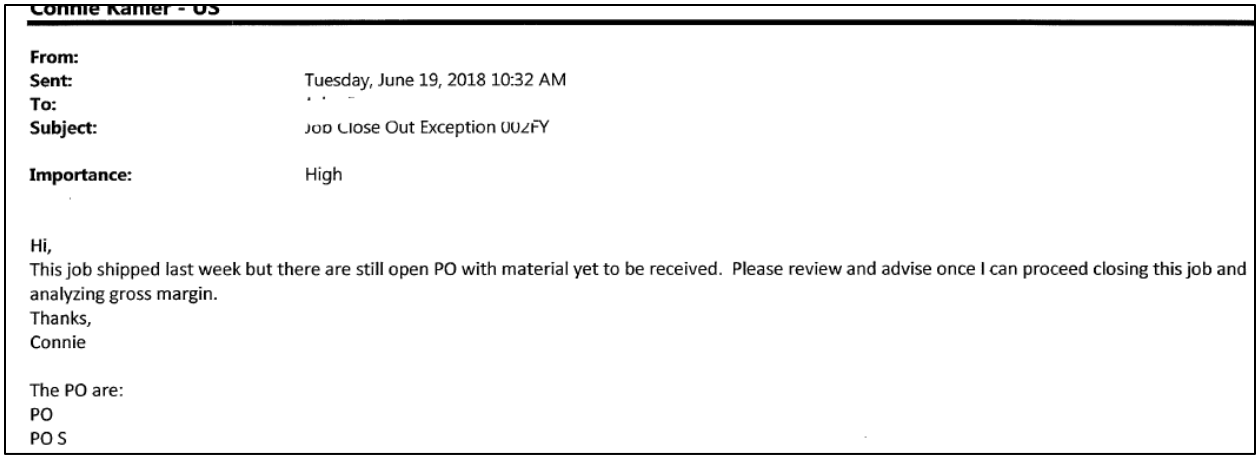
Figure 5. Part standardization policy email.

Job Close-Out Process

A variety of issues contributed to the differences in estimates for material costs of a job. Several inventory items changed from floor-stock to controlled-stock and back again. Floor stock items were intended to be immaterial dollar value parts that were not discretely tracked and routinely replenished. In contrast, controlled stock materials were charged to the production job and relied on system demand to initiate a reorder notification. Employees were often unclear as to what they could take freely and what they should record in the ERP system. Planning

personnel often overestimated material needs to minimize the risk of shortages, which would bring production to a halt. The social norm was that when the product shipped, the job closed. Since little detail was included in the price estimate, minimal inquiry into variances from estimates was possible. The result was that some products were under-costed for materials and some were over-costed, which made identification of trends difficult.

George and Duffy (2000) studied automated decision support aids and recommended providing warnings, explanations, direction of the bias, and personalized feedback. In the ERP system, once a job shipped or returned to stock, a system notification to close the job appeared. Despite warning prompts from the system that all expected material had not been issued to the job, the finance team ignored them and proceeded to close the job. The result was that material costs for the job could significantly vary from actual use and initial estimates. Therefore, I instituted a formal job close-out process. After a sales order was complete, employees reviewed the job to ensure all production steps occurred and all materials were issued. When material was not issued or under-issued, operations, inventory control, and planning teams received an alert email calling for immediate investigation (see Figure 6). If the bill for material estimates was too high, they adjusted down to prevent future overestimates. If the transactions should be in the ERP record, the inventory clerk would record them and investigate the reason the transactions were initially omitted to prevent future occurrences.



Connie Kanter - US

From:
Sent: Tuesday, June 19, 2018 10:32 AM
To:
Subject: Job Close Out Exception 00ZFY

Importance: High

Hi,
This job shipped last week but there are still open PO with material yet to be received. Please review and advise once I can proceed closing this job and analyzing gross margin.
Thanks,
Connie

The PO are:
PO
PO S

Figure 6. Job close-out example email.

When material costs exceeded estimates, the Controller conducted an inquiry to understand if this was due to estimating errors or if unexpected rework steps were performed due to failed in process inspections. Communication of clear expectations for rapid resolution timeframes with each team member was necessary to correct such issues. The requirement of adding rework steps to the jobs was critical; initially, these were only added upon request. This requirement provided potential resolutions without investigation by assuming the variances from estimates were due to incorrect initial projections unless the person who prepared the bill of material was intimately familiar with the build. Without investigation into why the variance exist, leaders at the SME might draw incorrect conclusions.

Almost immediately after implementation, the number of jobs that *closed with exception* rapidly reduced to the extent that the exception notifications became infrequent. This may be an indicator of rapid success or may simply reflect employee learning. If employees know that leaders will review variances and have the knowledge to correct them, they may eliminate them before further investigation is necessary. However, this prevents the organization from learning and does not make future decisions more accurate.

Implementation and Evaluation Stages

The eADR intervention implementations began in March 2018 and concluded in April 2018. Therefore, data from May and June for the years of 2017 and 2018 was relevant to determine if the labor and material estimates were more realistic regarding actual costs. Due to the cyclical nature of contracts, a month-over-month improvement was not consistently expected. A year-over-year analysis is applicable in this case.

I identified all sales associated with Product line A and compiled the estimates for hours and material costs to compare them to actual labor hours and material costs and calculate the percentage of variation. I used the percentage of variation in lieu of whole dollar variance to prevent a larger value variation from appearing to be more inaccurate than a smaller value error due to number rather than degree of estimate accuracy. Whole dollar variations are important for the organization but for an accuracy measurement, the percentage of the delta from expected to actual is more relevant to fine tune estimating practices.

Additionally, I recorded the customer attribute of intercompany versus external projects. For a variety of tax and reporting reasons, intercompany projects are subject to transfer pricing agreements. This was unlikely to impact the degree of estimate accuracy for material and labor content, but it was important to include as another potential analysis attribute due to the knowledge of the sale price and the cost to produce. Table 4 includes an overview of the results of analysis. A positive value indicated that actual values were less than estimated (an overestimate) and a negative value was an underestimate, indicating actual values were higher than estimated.

Table 4

Actual to Estimated Labor and Material Variances

Intervention	Labor Var %	Classification	Material Var %	Classification	Intercompany
Before	-77.64%	Underestimated	-44.67%	Underestimated	No
Before	-303.93%	Underestimated	57.83%	Over-estimated	No
Before	-106.21%	Underestimated	-106.73%	Under-estimated	No
Before	-115.94%	Underestimated	-19.15%	Underestimated	Yes
Before	-201.42%	Underestimated	-29.06%	Underestimated	Yes
Before	-190.55%	Underestimated	-71.30%	Underestimated	Yes
Before	-42.24%	Underestimated	-69.61%	Underestimated	Yes
Before	9.07%	Overestimated	-198.17%	Underestimated	Yes
Total Variation in absolute values	1047.00%		596.52%		
After	-141.42%	Underestimated	-13.42%	Underestimated	No
After	-240.76%	Underestimated	-11.93%	Underestimated	No
After	-84.97%	Underestimated	-5.63%	Underestimated	No
After	-10.44%	Underestimated	14.66%	Overestimated	Yes
After	-20.94%	Underestimated	48.95%	Overestimated	Yes
After	-129.59%	Underestimated	19.08%	Overestimated	Yes
After	18.48%	Overestimated	-0.37%	Underestimated	Yes
After	18.31%	Overestimated	-81.88%	Underestimated	Yes
After	27.52%	Overestimated	-43.75%	Underestimated	Yes
After	-149.84%	Underestimated	63.20%	Overestimated	Yes
After	-42.68%	Underestimated	43.29%	Overestimated	Yes
Total Variation in absolute values	884.94%		346.16%		
Change	-162.05%		-250.36%		

Implementation of all artifacts happened concurrently and each influenced multiple areas within the SME. Therefore, it was not possible to determine the cost element impact of each artifact. For example, the labor report influenced more reasonable labor hour estimates. However, not all decision-makers used the report in the same manner or focused on the same information within it. The operations manager may have recognized overly optimistic labor hour projections based on the labor report artifact. The sales team could have received similar benefits from the quote report demonstrating overall price inconsistencies and looked deeper into the price build up components to compare labor hour estimates for similar products. Furthermore, some participants used several artifacts and could have experienced combined influences from multiple sources. Because the estimate accuracy improved after introduction of artifacts, they clearly had a positive impact on decision-makers.

Material accuracy. To measure changes in estimate accuracy, I summed the absolute value of the material cost percentage variance by jobs before the eADR research (596.52%). The total absolute variation in estimate accuracy after the eADR research was 346.16%. The overall material estimate variation reduced by 250.36%, indicating that variation in material estimates decreased after artifact introduction. Material estimates were predominantly less than actual costs; 7 out of 8 jobs (87.5%) were underestimated. After the artifacts, 6 out of 11 (54.5%) of jobs met the requirements of the *underestimated* classification (see Figure 7).

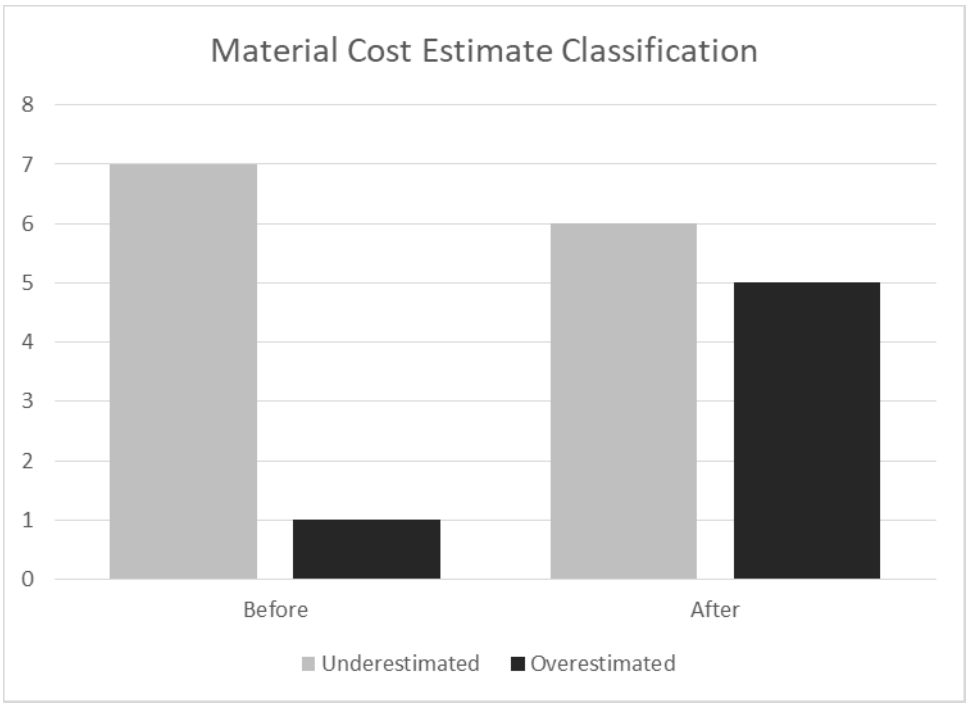


Figure 7. Material variance classification before and after eADR project.

However, a variation outside organizational targets of 15% remained. Therefore, an analysis based on customer type data was necessary (see Figure 8). All overestimated jobs after artifact implementation associated with intercompany projects.

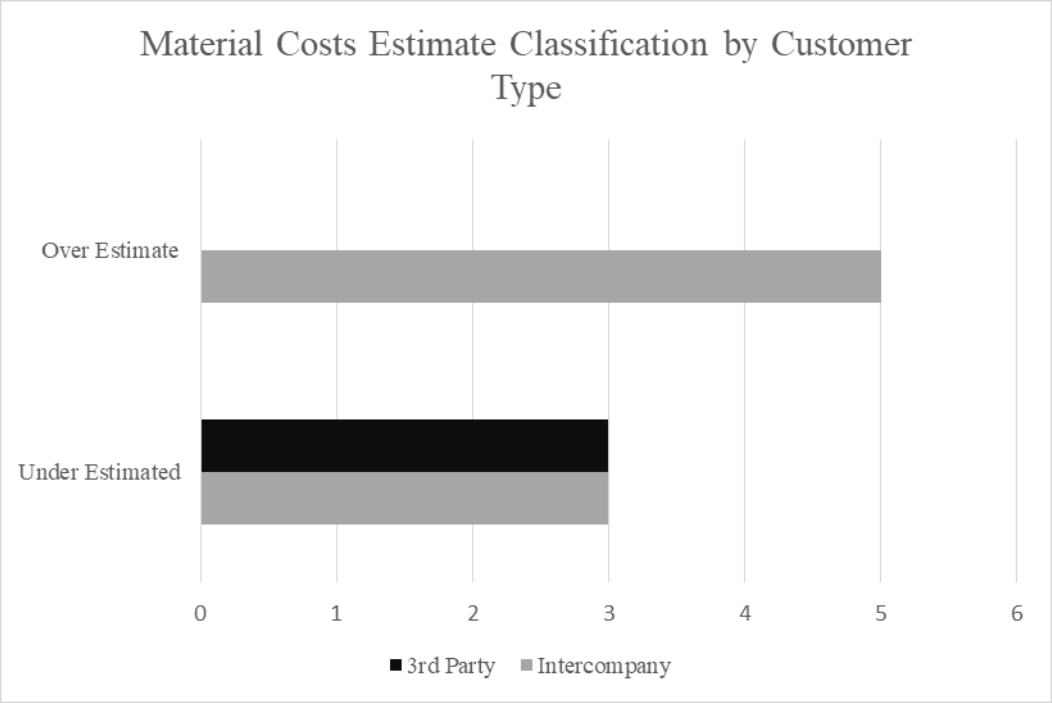


Figure 8. Material variance classification by customer type.

Labor accuracy. To measure changes in labor estimate accuracy, I summed the absolute value of the labor hour percentage variance by jobs before the eADR research (1,047.00%). The variation in estimate accuracy after the eADR research was 884.94%. The overall labor hour estimate variation reduced by 162.06%, indicating that variation in labor hour estimates decreased after introduction of the artifacts. Labor hour estimates were predominantly less than actual costs; 7 out of 8 jobs (87.5%) classified as underestimated. After the artifacts' introduction, 8 out of 11 (72.73%) of jobs classified as underestimated (see Figure 9).

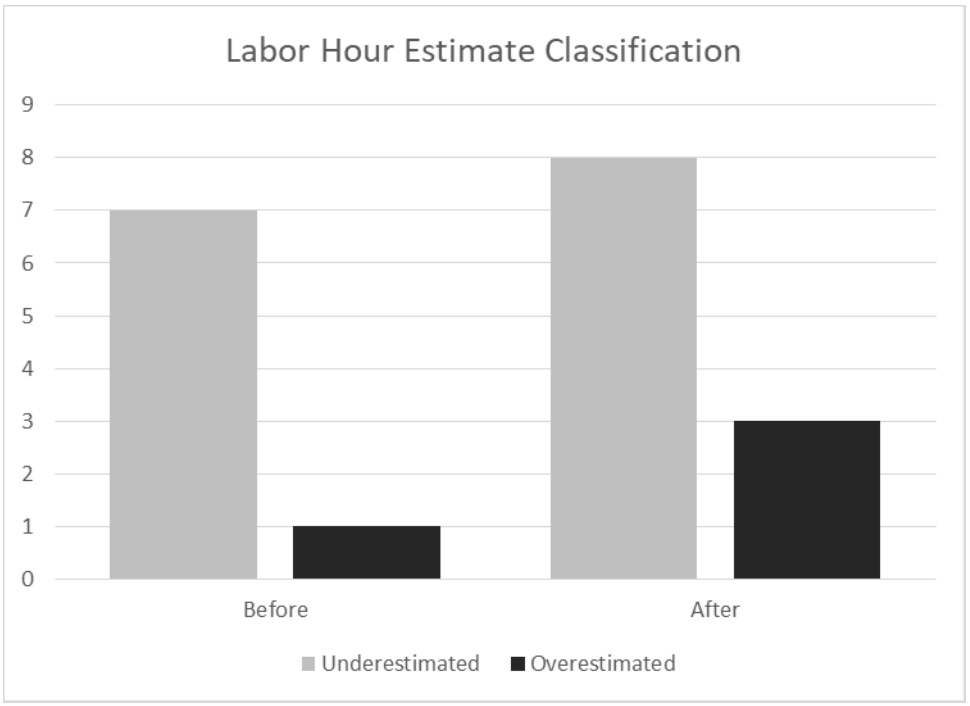


Figure 9. Labor hour variance classification before and after eADR project.

Similar to material estimates, most labor hour estimates were less than actual costs incurred before the artifacts. I performed the same analysis to determine if the volatility for this cost element also associated with customer type. Figure 10 illustrates this analysis and supports the conclusion that labor hour variations associated with all customers.

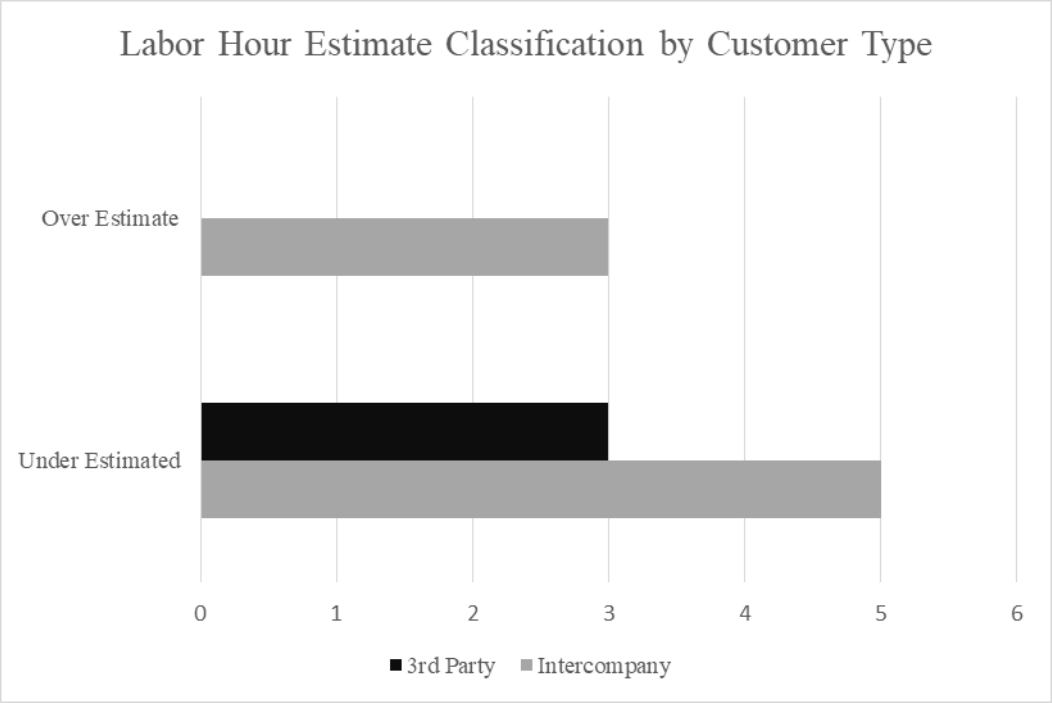


Figure 10. Labor hour variance classification by customer type.

Business capture impacts. I anticipated that the decision-makers might be concerned about loss of market share due to changing pricing practices. Table 5 is a report format designed to monitor quote *hit rate*. Based on the period of time selected, the report displays the total value of quotes by status. It calculates the hit or capture rate by summing the dollar value of contracts won divided by the dollar value of all quotes the SME prepared. I removed the source data at the request of the SME. Based on financial data analysis, this product line experienced a 36.11% revenue growth compared to the prior year. The quote hit rate improved by 37.8% from 14.9% in 2017 to 52.7% in 2018.

Table 5

Quote Hit Rate Report Format

Quote Status	2018	2017	2016	Grand Total
Cancelled	Data	Data	Data	Sum of data
Open	Data	Data	Data	Sum of data
Ordered	Data	Data	Data	Sum of data
Grand Total	Sum of data	Sum of data	Data	Sum of Data
Hit Rate	##.#%	##.#%	##.#%	##.#%

SMEs operate in highly fragmented industries against high levels of competition (Welsh & White, 1981). Reasonable profit margins and adequate sales volume are necessary for firm survival. Providing a complimentary analysis may not directly influence decision-making but serves a critical role. This report provided evidence that the changes the SME implemented did not prevent the organization from winning contracts and thus increasing total revenues.

Participant Reflections

Follow-up interviews with participants provided additional insights into their perspectives of the artifacts' influence on their decision-making process. The responses were primarily positive and provided evidence of increased ERP system adoption within the organization. One participant stated, "The system is more accurate than it has been in the past…The system seems to be more right than it is wrong…so I let the system guide me" (Supply Chain.KR.071618). Another noted,

> The quote report was extremely helpful. It makes it easier and more efficient for me to track down information. I think it cut down on data overload…you could really hone in

> on what you want to see instead of getting distracted by all the other information. It has increased my efficiency for situations like that ten-fold! (Estimator.CM.071218)

A production manager explained, “Pulling all that information…has been amazing and much easier to track labor hours and times on jobs” (Production Manager.JR.050718). An accountant noted, “Yes, it helps save a lot of time…I have more information now” (Accountant.LT.071618) while discussing the supplemental training provided to others on how to attach documents to data records within the system. The accountant discussed the results of the labor report and stated, “It’s even more helpful than the timesheets. Now I see employees are paying more attention. I have less corrections than I use to” (Accountant.LT.071618).

In response to the system after eADR intervention, an inventory clerk found that “It’s a little more useful” (Inventory Clerk.NG.071718). “As far as the data and showing us how to go through the system, it has helped me make decisions” (Production Manager.JR.071818). When asked their opinion of reduction of decision-making biases and the use of intuition, responses were mixed. One participant explained, “I use my intuition by knowing history and then I can bounce it all together, you know” (Supply Chain.KR.071618)?

Another discussed awareness of other employees’ overconfidence bias. “Now I’m recognizing it more and learning when to push for a breakdown or something” (Estimator.CM.071218). In response to the labor report, this participant stated, “They seem to be much more aware of how long it will take them to do certain things. I think we are moving in the right direction” (Estimator.CM.071218). Regarding intercompany pricing Estimator.CM.071218 stated, “I think people who are giving us numbers and everything are under a lot more pressure from multiple people.” Lastly, in response to the *hours to complete* estimates, this participant noted, “I also think we still have mood based hours,” implying that estimates reflected illogical

factors (Estimator.CM.071218). Another participant discussed the labor report's influence on estimates and stated, "It was basically how fast I could do it. Now that I kind of know the work of the company, it helps me to better quote it" (Production Manager.JR.071818).

Summary

This chapter included descriptions of the artifact designs and implementation processes. It also included the results of the estimate accuracy for two cost elements (material costs and labor hours) before and after the project. Additionally, I organized the before and after estimate accuracy results by intercompany and third-party sales in figures 8 and 10. Finally, the chapter included a review of the sales volume and quote hit rate. The next chapter includes discussions of these results in the context of the research questions and existing literature.

CHAPTER SIX:

DISCUSSION

This chapter includes discussion of the findings used to answer the research questions. It also includes the implications of the results of artifacts from this eADR method. The chapter concludes with practical recommendations for practice and contributions to research by providing insights into how a SME organization used ERP systems to mitigate cognitive biases.

The first research question was exploratory in nature and sought to understand how SME decision-makers use ERP systems and their outputs in decision-making processes. Using multi-round interviews and ranking activities during the diagnosis phase, the participants identified several concerns. Despite the variety of roles and decisions made, these findings suggest that concerns fall into three primary themes: data, human interfaces, and cognitive bias.

Findings regarding ERP outputs in the decision-making process align with prior research; the perceived value of the information to individuals outside the finance department was minimal (Teittinen et al., 2013; Ruivo et al., 2014). The theme of *data* (e.g., common meaning, incompleteness, and accuracy) was critical. Failure to maintain transactional information influenced decision-makers' reliance on the system (Koh et al., 2005; Koh et al., 2006). This research confirmed prior findings about system knowledge concentration in a small number of individuals (Maurizio, 2017). In this manner, this research contributes to the body of knowledge by confirming prior findings conducted using surveys, questionnaires, and interviews to identify challenges for ERP use by SMEs.

The second research question sought to determine how to design, implement, and evaluate several artifacts to reduce biases in the pricing decisions of the SME. The artifacts mitigated overconfidence bias, optimistic bias, planning fallacy, and representativeness. Based the results, the artifacts resulted in reduction of estimate variation for material costs and labor hours. A discussion on the interventions' influences on these cognitive biases appears in Figure 11. The artifacts also influenced the cost elements of labor hours and material costs.

	Overconfidence Bias	**Optimistic Bias**	**Planning Fallacy**	**Representativeness**
Quote Report	H	M	L	H
Training	M	L	M	H
Labor Productivity Report	M	M	M	M
BI Module	M	M	L	M
Cycle Count Process	M	L	L	L
Part Standardization Policy	L	L	L	L
Job Close-Out Process	L	L	L	L

Figure 11. Overall impact of artifacts on decision-making based on researcher evaluation and categorization of impact (H) high impact; (M) medium impact; (L) low impact

Based on our evaluation, the combined artifacts introduced did have a positive impact on the pricing decisions at this SME. Three of the seven artifacts introduced had impacts contrary to my expectations. The training report was anticipated to have an impact on the optimistic bias but the results were not apparent. However, it did influence representativeness which was unexpected. The part standardization policy, while important to the organization, did not demonstrate an influence on mitigating bias in the decision making process. Similarly, the job close out process had little influence on cognitive biases and errors. The remainder of this chapter is a more detailed discussion of results in Figure 11 organized by the research focus.

Overconfidence Bias

The quote report had the most significant impact on overconfidence bias. Decision-makers efficiently located all relevant records by product and compared estimated prices. For example, the estimating team participant demonstrated an increased awareness of the degree of inconsistency in historical data at the product level after using the quote report. In terms of complexity, the quote report was the simplest feedback tool. This supports prior research that concluded simple tools are necessary in SME environments (Millers & Sceulovs, 2017).

The labor report had a medium impact. It did not provide a direct price comparison, as the quote report did, and was less influential. For example, the labor report provided information regarding hours to build by job. However, it required the additional analysis step of dividing by quantity produced to perform meaningful unit price comparison. The user also needed to consider the current state of the build. In contrast, the quote report did not require a two-step analysis. Training helped employees acquire more information and increase the speed and ease at which they obtained it. This was a medium impact because it encouraged the use of increased data gathering, which demonstrated the variety of prices and reduce overconfidence.

The BI module also had a medium impact. Decision-makers learned much more detail about the organizational performance than before, but it was not as straightforward as the quote report. It required them to interpret the information and apply it. The BI tool facilitated feedback on an organizational level and marginally supported more detailed inquiry by decision makers.

The cycle count process had a medium impact because it provided insight into the level of accuracy associated with the ERP systems data. Insights regarding on-hand inaccuracies caused participants to question where in manufacturing the parts were actually used. It also introduced skepticism that the high margin jobs performance may be due to missing costs rather than actual increased efficiencies. Individuals make decisions in SMEs; therefore, the use of *self*

as a source rather can go unchecked. Decision-makers be unable to articulate why they reach a decision, prohibiting others from evaluating the quality of their decision prior to action. These circumstances can create a self-serving environment in which overconfidence increases. The quote report provided meaningful insights and reduced decision-makers reliance on intuition regarding how much a product costs to produce and how to estimated price to achieve a desired margin.

Optimistic Bias

The quote report also mitigated optimistic bias. While an overrun on a single project may be an anomaly, having the ability to show trends was helpful. This was particularly useful for intercompany transactions. The estimates for external customers improved after implementation of this artifact and intercompany estimates remained volatile. This may be due to both parties being agents of the organization and the influence of interpersonal relationships in the workplace (Uzzi, 1997).

The relationship between owners and employees is paramount; SME owners are closer to operational issues than in other organizations (O'Regan et al., 2005). Because both owners were involved in transactions in a sales capacity, they were more knowledgeable of specifics, which may have had an influence. Employees, aware that details are public and directly attributable to them, may have felt pressure to reduce estimates to please leadership. Equal attention was not applied to estimate accuracy for these transactions. This may be because addition markup was applied by the sister division prior to final sale, which presented an additional opportunity for improved financial performance rather than a definitive conclusion on profit achieved. Employees partially experienced the phenomenon that Kahneman and Lovallo (1993) noted regarding a forecast becoming firm commitment, but did not experience negative repercussions

when it was absent because costs remained within the consolidated financials. In contrast, external sales were under more scrutiny due to third party involvement. The introduction of a key performance indicator (KPI) by cost element rather than overall gross profit margin allowed SMEs to identify estimate accuracy and refine processes globally.

Originally, I anticipated that training would impact bias as decision-makers would be able to obtain more information, see the less desirable performance across a product class, and include more realism in their forecasts. However, I did not observe that plans for an overly optimistic future changed after training. Therefore, I rated the impact of training as low in mitigating this bias. This may be because optimistic bias is future-oriented and such future oriented information does not yet exist.

The labor report had a medium impact on the estimates regarding how much product could be produced and team member achievements. The production manager began to make comments acknowledging how long individuals worked on a particular job. Previously the labor estimated were based on the amount of time he would take to perform the tasks under ideal circumstances rather than considering the capabilities of the actual workforce.

The BI module also had a medium impact. This enhancement provided access to data in new and interesting formats, but was based on history rather than projecting future performance. Key decision-makers' behaviors reflected that were still comfortable with a high degree of risk-taking regarding how to achieve a sales price rather than a critical review of pricing using this tool. This conclusion is based on the continued persistence of price to win adjustments for larger contracts prior to negotiations or sale price feedback from the customer.

Planning Fallacy

Training had a medium impact on the planning fallacy. More decision-makers effectively navigated the system and used data regarding job performance by production station. However, I did not observe a significant number of employees discussing *discoveries* they made. Instead, conversation tended to be about the new artifacts. This lack of evidence may have been due to the time during which training occurred. It was a particularly busy time for the organization and employees may have lacked the time to practice newly acquired skills.

The labor productivity report also had a medium impact on the planning fallacy. While useful to identify issues, the correlation between this information and job estimate was not straightforward, which may have inhibited its influence. Additional interventions are available, however. Buehler et. al (2010) recommended considering scenarios from others' viewpoints rather than the individual picturing themselves completing tasks to estimate steps rather than a whole. It is unknown whether standardizing the estimated labor forecast template in a more compartmentalized fashion would improve labor estimates in SMEs. This would require comparing the informal method in this eADR (i.e., the estimator inquiring into who would perform on the job) to a more structured template to shift operations team decision-makers' viewpoints from internal to external.

Representativeness Bias

The quote report was the most impact, followed by training, in mitigating this bias. Similar to the findings of Craig, InduShobha, and Donald (2003), more experienced decision-makers began to ask questions before concurring with a proposed price due to context. For example, when comparing the price of a product X build two years ago to a product X built

today, changes in the labor and material needs based on different scopes were more apparent to decision-makers. This allowed them to quickly set aside anomalies.

Training had an unexpected high impact in this area. Decision-makers could find more data, which reduced some long-held but unsupported organizational beliefs. The sale of basic products was rare at this SME; most contained security features and aspects to ruggedize the unit. Before the project, employees often categorized the product in three broad categories. After the training, decision-makers exhibited more appreciation of the level of complexity and changed their estimates for time and price of goods.

The BI module also had medium impact on this bias. Participants reported that the BI module contained useful information. However, employees were interested in the data but not in hunting for it, even if that only entailed a few mouse clicks. Going from no interest to full engagement in a system takes time. By modifying the process slightly (e.g., emailing the information), decision-makers were more likely to respond. In contrast, interview responses did not indicate that employees independently sought this information.

Research Implications

In addition to practical implications, this research also contributes to the existing literature. The results of this research provide insight into the use of ERP systems and their outputs for decision-making in the SME environment. Furthermore, this project included the design and implementation of several artifacts to mitigate four cognitive biases and decision-making errors. Based on the data, feedback was a successful tool. The findings of this study suggest ways in which to introduce feedback to employees. Additionally, I identified how other

biases (e.g. loss aversion & framing) may counteract those identified in this research to produce a more realistic sell price.

Feedback

Despite reliance on individuals for a broad range of decisions, little feedback was present to validate the quality of the decisions that employees made. During diagnosis, five interviewees reported they became aware of the quality of their decisions when they received negative feedback. In the SME environment, unless advised otherwise, employees presume that decisions are correct and do not changes to their methods. Unfortunately, due to limited resources, feedback may only occur after disastrous choices that require corrective action. Therefore, less critical low-quality decisions may routinely occur without owners or leaders becoming aware. The quote report, labor productivity report, and BI module all served as feedback mechanisms for decision-makers.

Loss aversion and framing. Loss aversion and framing techniques helped decision-makers consider alternatives. After establishing bottoms-up estimate practices, employees agreed that only the department providing the estimates should modify them. This meant the sales team could only modify the price by adjusting the profit markup or requesting a price-to-win strategy in which the customer's expected price rather than the cost to produce was the driving factor.

Sales team members respond to the idea of *giving up potential profit* as a loss, supporting prior research (Kahneman & Lovallo, 1993). When they stated a price was too high for the market and requested a reduction, the estimators consistently responded by asking if they would like to reduce profit. This simple framing technique changed the sales person's mind or limited the price decrease to allow for direct cost recovery.

General eADR Project Observations

In addition to theoretical research contributions, the eADR method's structured and reiterative process was beneficial as well. The process provided an opportunity for decision-makers to ask questions, obtain training, and become more comfortable with the ERP system. Because they participated in the artifact design, employees exhibited increased acceptance of the ERP. Most decision-makers reported an increased understanding of actual performance. Estimating personnel reported that labor estimates now include more granularity. When there is a challenge to a cost estimate, decision-makers are better able to justify their estimates. The number of questions related to the ERP and reference to its data has also increased after implementation of the artifacts. Four general project execution recommendation emerged during the design and implementation phase of this eADR project that suggest the importance of context, focus, anticipation, and timeframes.

Consider external factors. As part of the eADR process, careful consideration of external factors is necessary. In this study, the quote report was a success despite pressure from the sales team to close deals due to oversight by other stakeholders. Understanding the decision-makers' motivations and control environment before attempting to enhance it was critical.

Anticipate work arounds. Once employees develop a solution, they should stop and consider workarounds that could impact the desired outcome. In the case of the labor report, they could manipulate the productivity metric. SME owners should be aware of this so that metrics implemented influence actual employee behaviors desired, rather than just making the numbers look better on a report.

Expect distractions. If the eADR project was a success, the SME should effectively anticipate and manage distractions. As decision-makers become more comfortable with the ERP

system and its data, they may want to resolve negative findings. The ERP is a good source of information regarding what is working and not working. SMEs should avoid letting leaders make drastic changes after using the ERP for identification but ignoring its continued value. Instead, owners should use the ERP to support change efforts with metrics (e.g., benchmarks for success).

ERP engagement process. eADR project leaders should to be aware that initial excitement may be high; yet, the actual use of new tools takes time. The goal is for employees to independently seek information from the ERP. Project leaders should be flexible and set milestones to mark incremental progress. For example, the goal of 100% ERP use is lofty. A milestone goal (e.g., decision-makers using the output of the ERP) ensures that the system and its data influences decision-making processes at SMEs even without total adoption.

This chapter presented the findings associated with artifacts designed and implemented at this SME. I used these findings to answer the research questions presented in chapter one. This chapter included a discussion of the research and practical implications that resulted from this eADR project.

CHAPTER SEVEN:

CONTRIBUTIONS, LIMITATIONS, AND FUTURE RESEARCH

The goal of this AR was to understand how the ERP system could be used to mitigate decision-making bias in SMEs. As discussed in chapter one, our first research goal was to understand how the ERP system and its outputs support SME decision-makers. Our second question required the design, development and implementation of new artifacts specially targeted to mitigate cognitive biases and decision errors identified in this SME organization.

This eADR research included multiple cycles of diagnosis and design. Artifacts included new policies, procedures, system modules, and reports. I used a variety of data collection techniques to gain rich insights into employee concerns and the results of interventions. The results of this study indicate that approaching biases to improve decision-making using eADR is practical and beneficial.

Contributions

This study has produced several academic contributions. First, the research revealed how artifacts such as policies, processes, reports, and system modules help SME decision-makers mitigate cognitive biases and errors. Particularly, it demonstrated how feedback and the use of other biases (e.g. loss aversion and framing) can mitigate overconfidence bias, optimistic bias, planning fallacy and representativeness bias in a real world setting. Second, this study confirmed that the eADR process can be an effective means of implementing incremental changes, evaluating impacts, and increasing engagement in SMEs. Lastly, this study confirmed prior research regarding challenges of ERP use in SMEs.

Practical contributions also resulted from this research. Because an individual's independent decision-making can have long-term implications for organizations, SME employees may benefit from understanding cognitive biases such as overconfidence, optimistic bias, representativeness, and planning fallacy. SME leaders must identify aspects of decisions that require more oversight. Implementation of tools that facilitate increased oversight and minimize information overload may allow more individuals to monitor a wider range of business activities. Developing appropriate feedback mechanisms encourages individual decision-makers to contemplate logical and data-driven considerations.

SME leaders should also be aware of the factors that inhibit employees' reliance on ERP systems. To that end, this research demonstration an effective approach to process improvement related to ERP systems and outputs for SMEs. For small businesses with limited time and resources, such an approach may be beneficial. Specifically, this research provided specific examples of complimentary SME tools that similar SMEs may find helpful in their organizations.

Limitations

One limitation of the present study was that conclusions reflected the decision-making behavior of individuals within a single organization. It is possible that these findings are isolated occurrences that are not generalizable to all SMEs. However, due to the alignment of the findings with those of past researchers, there is increased confidence that the conclusions are accurate. It would be useful for future researchers to investigate other manufacturing firms and focus on other types of SMEs to further confirm the findings.

A second limitation was the introduction of all artifacts into the organization concurrently. It was impossible to discern the precise impact of any one artifact. Better

understanding of such impacts would benefit SMEs seeking to ensure that they expend resources in the most efficient manner to support improve decision-making.

A final limitation was that I, as the researcher, was embedded within the organization in a key leadership position. To limit the influence of this limitation, I selected participants solely based on their role within the organization. Future studies by non-employee research practioners may determine the reliability of the present findings and determine whether the leadership level of the research practioners influences outcomes.

Recommendations for Future Research

Based on the results that intercompany price component estimates did not change in a similar manner as external customer estimates, more investigation is warranted in this area. The influence of interpersonal relationships on estimating practices in this environment may provide more insight into antecedents that limit estimation accuracy when interorganizational transactions exist. Future researchers could investigate the use of an individual feedback mechanism in an SME environment to discern which type of artifact is most useful. This research would be valuable to small businesses who need to secure external resources to support the design, development, and deployment of such artifacts with limited personnel and funds.

The present research focused on one SME located in the United States. Future researchers should investigate cognitive biases in the pricing decisions of SMEs in other countries and industries. Doing so may assist in determining whether these finding are attributable to other SMEs and if cultural considerations also influence data and analysis. As more SMEs participate in a global economy, better understanding the nature of these biases would be beneficial to all SMEs.

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APPENDIX A: INTERVIEW GUIDES

Primary Interview Format

Before we begin, I'd like to tell you a little bit about the study.

We are interested in understanding the extent ERP information is used in the decision-making process at small firms for a particular role. I will be asking a few questions to help guide our conversation surrounding circumstances in which you rely on information obtain from the ERP, other sources of information you use and your opinions and recommendations as they related to the ERP system.

What you say to me is important so I'd like to take notes. To make sure my notes correctly represent what you say, I would also like to take a sound recording. All information you provide will be kept confidential, including the recording. Would that be ok?

1. What is your name and current job title?

2. How long have you been in this role? Do you have prior experience in this role?

3. How long have you used the current ERP system?

4a. Describe a decision that you make that uses information from the ERP system.

4b. What information does the ERP provide related to this decision?

4c. Which pieces of information the ERP provided did you use?

4d. Is there any other information used in the decision that does not come from the ERP system?

4e. How did you evaluate the goodness of the decision you made?

5a. Describe a decision that you make that does not use information from the ERP system.

5b. Why is ERP information not used?

6a. Describe a decision that you make where ERP information is available but is not used.

6b. Why is ERP information not used? If reasons are not volunteered the next set of questions are asked to prompt the interviewee to consider various aspects.

I'd like to explore the reason(s) you provided for not using ERP information for decision X.

6c. Were there characteristics of the system itself that influenced your choice to not use the information? If yes, please explain.

6d. Were there characteristics of the data itself that influenced your choice to not use the information? If yes, please explain.

6e. Were there characteristics of the decision itself that influenced your choice to not use the information? If yes, please explain.

7. Do you have any instances in which you would like to use the ERP data but could not?

8. Please provide your opinions on the use of the ERP system on decision-making in your position. What can be done better? How could the ERP system and its use be improved?

Thank you for your time and valuable insight. If I have any follow up questions, may I stop by?

Secondary Interview Format

Based on other interviews, a list of reported factors that influence ERP use has been compiled. As a result, I have two follow up questions.

1a. Do these other reasons for not using the ERP influence your use of the system? Incomplete/Missing Information, Data Accuracy, Data Consistency, Inconvenient Access, Intuition – ERP not needed. For each positive response, the interviewee provided an example.

1b. In terms of level of influence, how would you rank these factors' importance to you?

2. How do you solve or compensate for these other issues in your decision-making approach today?

APPENDIX B: INTERVIEW CODING SCHEME

Primary Interview Coding Scheme

Codes shown in boldface and italicized are codes that emerged from the data based on open coding after the interviews were completed. All other codes were initially developed based on the literature review.

Coding Scheme

General
- ***Experience in role***
- ***Experience with system***

Decision Types
- Prior decision
- Similar decision
- Repetitive decision
- New decision
- ***Structured decision***
- ***Unstructured decision***
- ***Strategic***
- ***Tactical***

Cognitive Biases
- Optimistic
- Hopeful
- Confident
- Unsure
- Guess
- ***Memory***

Data Characteristics
- Useful
- Excessive/Overload
- Inaccurate
- Accurate
- Timely
- Difficult to obtain
- Format
- Unknown
- Missing/Incomplete
- Override

- Reject

- ERP Characteristics
  - Navigation
  - Training
  - ***Perceptions***
  - ***Flexibility***
  - **Stability**
  - **Accessibility**
- Decision Environment
  - Fast
  - Easy
  - Routine
  - New
  - Hard/difficult
  - ***Uncertain***
- Decision Optimization
  - Restrictions
  - Timeline
  - Changing/evolving
- Decision Results
  - Accurate
  - Inaccurate
  - Acceptable
  - Unacceptable
  - Checks and balances
  - ***Feedback***
- Decision-making Style
  - Individual
  - Group
  - Consensus
  - Intuition/Gut Feeling
  - Data-based
- Decision Stakeholders
  - Individual
  - Group
  - Owner
- Opinions & Recommendations by Decision-Maker(s)
  - Modification
  - Training
  - Add
  - Remove
  - Change
  - Needs

Other sources of information

- ***Prior experience***
- ***Documents***
- ***Visual observation***
- ***Inquiry with others***