INFORMATION TECHNOLOGY (IT) AS A MECHANISM TO BUILD TRUST AND FOSTER COLLABORATIVE INNOVATION IN THE BUYER-SUPPLIER RELATIONSHIP

by

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Submitted to the MIT Sloan School of Management and the MIT Engineering Systems Division in Partial Fulfillment of the Requirements for the Degrees of

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ABSTRACT

As companies attempt to remain competitive throughout increasing market forces, many firms develop key operational strategies to differentiate themselves. One method that many companies such as Amazon, Dell, and Toyota, have established a competitive advantage through is supply chain management (SCM). One aspect of a disciplined and effective SCM program is supplier management, both from a risk and cost perspective. In this paper, the author explores an area oft-forgotten when dealing with suppliers: trust. During a research project at Raytheon Integrated Defense Systems in Andover, Massachusetts, the author strove to learn how the dynamic of trust in a buyer-supplier relationship affects the companies' interactions, and how SCM leaders can influence this dynamic. First, through an examination of the available literature, the author presents an alternative view of the buyer-supplier relationship, viewed through the lenses of game theory and behavioral economics, in order to develop an impetus for change. Using an existing information-sharing information technology (IT) platform at Raytheon, along with extensive surveys of Raytheon suppliers and employees, the author answers the question: Can trust be built through sharing information in a systematic process through an IT platform? Results of the analysis show that there is a distinct possibility for companies to build trust with their suppliers through "opening up" and sharing information, which will ultimately facilitate collaborative innovation between the two organizations. In determining the types of information to share, the author generalizes the most useful type of information into categories applicable across various industries. Mainly, suppliers most desire and can utilize information that allows them to make more accurate and timely decisions, and likewise abhor information sharing and requirements that add burden to their workday. When determining which suppliers to share information with, companies need to develop some form of objective criteria to rank the potential impact of engaging specific suppliers. As each company's individual cases will differ, the author outlines a process to select Raytheon suppliers as an example of a methodology that others can follow.

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1. INTRODUCTION

1.1. SUPPLY CHAIN MANAGEMENT (SCM) AS A STRATEGIC DIFFERENTIATOR

As companies attempt to remain relevant in increasingly competitive markets, many look to find strategic areas to differentiate themselves. Many companies refocus on their core competencies, outsourcing and offshoring less value-adding processes. Over time, this has led to an increase in partnering between firms and the rise of supply chain management (SCM) as a key strategic differentiator between firms. SCM can be a key source of power that helps drive the success of a company, as seen across many industries by leading companies such as Wal-Mart and Toyota.

When firms shift to a closer partnering model, the structure of their relationships often changes by necessity. Stemming from the era of mass production, many supply chains were loose, vertically integrated networks built around arm's-length relationships between companies and their suppliers. Since the end of the twentieth century, however, increased global competition led many companies to realize closer partnerships were needed for success, contrary to a traditional modus operandi of arm's-length relationships. In many cases this shift in organizational structure is necessary for reasons beyond simply gaining efficiencies and maintaining competitiveness: "[many companies] have discovered that in order to survive, it is imperative for them to come together for mutually beneficial reasons based less on power play and more on value exchange" (Sahay 2003).

Strategic partnerships are becoming so important in fact, that many companies and industries have changed how they look at their supply chains. The term itself, *supply chain*, "was appropriate for the old hierarchical corporation, but it is not for the twenty-first century firm. Today chains are becoming value networks" (Tapscott and Williams 2006). This shift in mindset from a *supply* chain to a *value* chain helps frame how firms relate to one another. With global competition continuing to increase, "the issue isn't whether companies should turn their arm's-length relationships with suppliers into closer partnerships, but how" (Liker and Choi 2006).

1.2. OPPORTUNISM IN THE VALUE CHAIN

It may be easy for firms to realize they need to develop closer relationships with their suppliers, but it is hard to put that realization into practice. It is inherently a difficult task for individual firms in a value chain to collaborate and coordinate because there are often incentives for them to each maximize their own position, often at the expense of another firm in the chain (Dyer 2000). When those kinds of incentives exist and companies view their relationship with suppliers in "zero-sum"

terms, there is an inclination for companies to turn to opportunism and exploit any chance they can to gain an advantage. "Thus, firms do not naturally trust each other, share information, or engage in other activities that result in productivity improvements for the production network as a whole" (Dyer 2000).

It is not unreasonable to expect companies to maximize their own interests. Increasing shareholder value is a key assumption of modern economic theory after all. A problem arises when "companies assume, wrongly, that when they do so, they also maximize the supply chain's interests" (Narayanan and Raman 2006). In their study of more than 50 supply chains, Narayanan and Raman found that companies "often didn't act in ways that maximized the network's profits; consequently," resulting in poorly performing supply chains (Narayanan and Raman 2006).

If a company only did business with its partners once, there would be no reason to worry about optimizing the entire value chain because no benefits would ever be seen down the road. But what happens when there are repeated interactions over time between companies? This scenario is more indicative of modern business, and a question business leaders ought to ponder. When companies continually seek to gain the most favorable position, competitive terms, and economic efficiencies for themselves – at the expense of their channel partners - it kills trust and goodwill. They will drive channel members to opportunistic behavior, which is often answered with retaliation, starting a downward spiral of relations. Ultimately, if this happens, who wins? Companies can better serve themselves, as well as their partners, employees, and shareholders, when they realize that "over the long run, they can do better by developing a pattern of mutual cooperation with one another" (Axelrod 1984).

1.3. Information Sharing and Information Technology (IT)

In addition to SCM, many companies also employ information technologies (IT) assets as a means to strategically differentiate themselves. IT can bring benefits of its own, but also "supercharge" other competencies, including SCM. "Collectively, [IT investments] help to build and sustain supplier relationships and, ultimately, enhance performance and augment a firm's competitive advantage" (Sriram and Stump 2004).

Are these two seemingly unrelated subjects, trust and information technology, somehow linked? Can greater trust, built in part by sharing information over an IT platform, help curb opportunism in the value chain? The open sharing of key information and ideas develops trust because it assures companies of the assessment they make of others' intentions (Nambisan and Sawhney 2008) (Sahay 2003). Also, sharing vital information builds trust by creating a shared sense of

vulnerability and discourages the misuse of the information for opportunistic behavior (Sahay 2003). Copious volumes of business information already pass within and between companies via their IT infrastructures. Can supply chain IT also deliver "trust-building" information? "IT is, first of all, a transport mechanism--it carries digital information just as railroads carry goods and power grids carry electricity. And like any transport mechanism, it is far more valuable when shared than when used in isolation" (Carr 2003).

The realization that sharing information can build trust leads to several important questions. How can companies share information effectively? What information should they share? For companies that realize benefits from information sharing, can they institutionalize it into a business process? It is the author's belief that this is definitely possible. Current research suggests that successful companies are engaging in new "collaborative communities" and harnessing technology "in the hands of a more knowledgeable workforce to offer fundamentally new approaches to organizing and managing in a networked world" (Applegate 2006).

1.4. Research Motivation and Goals

The research for this thesis is the extension of previous work by Akiva Holzer, MIT Leaders for Global Operations Fellow '09. He researched the extension of a proprietary platform for sharing information with a company's key suppliers to enable more efficient supply chain integration. During the course of his research, Holzer concluded that effective information sharing in a supply chain is plagued by trust issues, as well as problems that make such a system difficult to scale to a large number of suppliers (Holzer 2009). This research expands upon his work, focused on the following goals:

- Learning how information technology (IT) alignment and information sharing affect perceptions of trustworthiness in the buyer-supplier relationship.
- Learning how trust affects companies' desires and tendencies to integrate together.
- Determining if higher trust and integration between buyers and suppliers can lead to collaborative innovation and problem-solving.
- Determining what kinds of information sharing will lead to collaborative performance gains.
- Helping companies determine the extent to which to scale information sharing to their supplier base.
- Developing a framework firms can use to guide their partnering initiatives, build trust, and foster collaborative innovation and problem-solving.

1.5. *Research Context*

This research was conducted with the cooperation of Raytheon Integrated Defense Systems (IDS) at their Integrated Air Defense Center in Andover, Massachusetts. Raytheon IDS is one of six business units in the Raytheon Company and is a leading integrator of defense systems. Raytheon is a technology leader specializing in defense, homeland security and other government markets, providing state-of-the-art electronics, mission systems integration and other capabilities in the areas of sensing; effects; and command, control, communications and intelligence systems, and mission support services. They serve a strong international and domestic customer base, including the U.S. Missile Defense Agency, the U.S. Armed Forces and the Department of Homeland Security and employ over 73,000 worldwide (Raytheon Company 2009) (Raytheon Company 2008).

Raytheon has a reputation for continuous improvement in their manufacturing and operations and has received numerous Shingo Prizes, including a North American Shingo Prize and two Northeast Shingo Prizes at the Integrated Air Defense Center alone (Raytheon Company 2008). The Shingo Prize recognizes companies that achieve world-class manufacturing status around the globe (The Shingo Prize 2008).

Raytheon's Integrated Air Defense Center (IADC) is a 1.5 million square foot multidisciplinary center with over 4,000 Raytheon employees. IADC houses manufacturing specialties including circuit card assembly and hardware integration, as well as numerous other functions including engineering, materials analysis, integrated supply chain, operations, whole life engineering, quality, information solutions, finance, and contracting (Raytheon Company 2009).

Numerous situations early in the decade converged to place the Integrated Air Defense Center in a precarious business position. Costs were increasing, customers were unhappy, and there were adversarial relationships with their union workforce, including a six week strike in 2000. IADC needed a turnaround, and they found it in a new commitment to operational excellence. One of the key innovations that sprung out of their crises was the development of Virtual Business Systems (Raytheon Company 2009).

Virtual Business Systems (VBS) is Raytheon's real-time information sharing platform. It is developed in-house by operations-experienced personnel, in support of all aspects of operations in the IADC. VBS is developed on LabView, a commercial off-the-shelf software platform normally used in conjunction with automatic test equipment (ATE). VBS allows for the rapid prototyping, development, and deployment of near-real and real-time information sharing "dashboards" drawn from information across multiple corporate databases. This information sharing allows efforts such

as shared communications and problem-solving, cause and effect analysis, display and analysis of key business and manufacturing metrics, as well as many other functions. Ultimately VBS contributes a great deal to a transparent organization at Raytheon, where employees at all levels can see and solve problems, and make decisions based upon accurate and timely information (Raytheon Company 2007).

This research stems from a project at Raytheon's IADC, and their desire to learn how to gain value from using their Virtual Business Systems with external suppliers. Previously, VBS had only been utilized within Raytheon. However, seeing the opportunity for expanding VBS's role and impact, key leaders at Raytheon decided to pursue extending VBS functionality to sources outside Raytheon with the ultimate goal of integrating a leaner supply chain enterprise. During his research, Holzer established a working prototype for "Supplier VBS" with a handful of functional dashboards accessible to two suppliers. Before moving on to a larger pilot program with additional suppliers, this research project sought to answer two main questions for Raytheon: (1) with which suppliers should they share information, and (2) what information should they share with those suppliers.

1.6. *Outline of Thesis Chapters*

Chapter 2 will help build a case for companies to build trust with their suppliers in search of a more integrated value chain. A review of the available literature will highlight for supply chain executives the importance of pulling collaborative innovations out of their relationships with suppliers, but also the natural barriers to effectively doing so: namely, a lack of trust and opportunism that arises in individuals and the companies they work for. Using both game theory and behavioral economics as lenses, it becomes clear these problems are natural and avoidable. The argument will be made that trust-building can possibly be institutionalized as a process, guarding against human tendencies to exploit a competitive advantage for short-term gains.

Chapter 3 will help the reader conceptualize trust as a factor leading to collaboration in the value chain. Building upon previous research and utilizing a technique known as Structural Equation Modeling, the author uses data generated through a survey of over 250 Raytheon suppliers to develop a conceptual model describing the process of building trust. This model is used later to develop a framework for companies to foster trust with their suppliers.

Chapter 4 first seeks to answer the question "with which suppliers should companies share information?" Using data from Raytheon contracts and supplier performance as an example, the author details a generic methodology for how a company can build its own algorithm to determine

the highest "bang for the buck" suppliers to engage in a campaign of information sharing. It then uses survey data to derive a framework for information sharing that helps companies understand what information to share with suppliers.

Chapter 5 reviews the limitations on this study and highlights future research to overcome those limits, as well as areas to expand into for greater knowledge of the dynamics of trust in value chain relationships. The author draws upon experience during the research project and data from the analysis to summarize conclusions of the research and highlight important managerial implications for companies across various industries.

2. BACKGROUND

2.1. *OVERVIEW*

This chapter begins by highlighting the importance of collaboration and innovation in the value chain. Firms' views of partnering with their suppliers are examined, as well as the barriers that prevent supplier integration, both from the organization and individual level. From there the author explores the use of game theory as a lens to understand problems that arise in the buyer-supplier relationship, namely trust issues and short-sighted opportunism that can arise. Also utilizing some new perspectives derived from behavioral economics, the author investigates the predictable shortcomings in human patterns of thought and how those might be of concern to supply chain executives. Collectively, this review of available literature coalesces around the proposition of building trust with suppliers by openly sharing information, in this case through an IT platform to establish trust-building as a process.

2.2. *COLLABORATION AND INNOVATION IN THE VALUE CHAIN*

Greater integration and closer relationships between companies in a value chain provide the opportunities to achieve several benefits not previously available to any single organization in the chain. When firms form closer partnerships with a shared vision and sense of purpose, they have the ability to cooperate, collaborate, and innovate together like never before. In the previous archetype of arm's-length relationships, each company sought to improve its own costs and efficiencies, unconcerned with benefits or costs incurred by others in the value chain. This practice came at a detriment to the overall chain, leading to local, as opposed to global, optimization. Under closer relationships, however, "collaboration allows companies to manage uncertainty... and achieve global optimization" (Simchi-Levi, Kaminsky and Simchi-Levi 2004).

Moving from arm's-length relationships to close partnering can be a significant event for a company. Many people in the organization may not see a cause for change, especially if their firm is the dominant player in a value chain. Many organizations may fail to see the full benefits within the chain. Instead, they remain focused on local optimization, not realizing the trickle-down benefits through global optimization. Moving to a mindset of global optimization takes a great leap of faith on firms' parts: "Collaboration will be the healthiest when everyone involved with the initiative is convinced that the initiative will provide value for his or her organization" (Mentzer 2009). When companies seek to improve their operations through better collaboration with their suppliers, Grover, Lau, and Sharma highlight that they will need to address their own internal challenges

before dealing with key stress points that strain relationships with suppliers (Grover, Lau and Sharma 2008).

Successful value chains realize the benefits from collaborating and seeking global optimization of their systems: "Collaboration changes the working relationship in ways which enhance the value derived from each other. They also allow lower costs and risks, and synergies, so that the net value delivered through this value chain is much higher than others in the industry" (Sahay 2003). As the value chain improves together, firms and their channel members gain a larger share of their market, and each are able to reap the benefits. Even if a firm gets a smaller "slice of the pie" from within their value chain, they still can benefit if the "pie" is larger than it was before.

Companies skeptical of closer partnering with their suppliers may fear losing a competitive advantage within their network. Indeed, many smaller firms in a value chain may be doubtful, afraid of ceding even more power to the central firm. When executed well, however, the benefits of closer partnerships in a value chain aren't held captive by the central firm. A study by Subramani provides "evidence that suppliers can benefit by participating in supply chain management initiatives of network leaders." (Subramani 2004).

The real key to globally optimizing a value chain is for companies to ensure they view the relationship appropriately. Dunn and Young point to a critical success factor from a study of supplier development initiatives. Success requires a "paradigm shift from 'us versus them' to 'we.'" Firms in their study avoided thinking of the relationship in terms of a zero-sum game. They realized that when companies assist their suppliers, they are in reality helping themselves (Dunn and Young 2004).

Closer partnering, collaboration, and innovation between companies delivers longer term benefits for all parties. Smaller firms will benefit by serving their other customers better, gaining more customers, and reducing their costs within the value chain. In addition to reducing costs and gaining increased responsiveness from their suppliers, larger firms can use closer partnering and innovation to improve all the members of its value chain: "Upgrading the skills of [an] inferior supplier not only improves the quality of the weaker supplier but also stimulates long-term competition" (Dyer 2000).

The benefits derived in the value chain clearly make it desirable for companies to move to closer collaboration. To fully achieve this, however, requires sharing more information than would be done in a traditional business setting (Petersen, Ragatz and Monczka 2005). This supports the belief that trusting ones channel partners is an imperative, because when exchanging proprietary,

sensitive transactional information, there is "a premium on trust between trading partners" (Young, Carr and Rainer 1999). In their study of value chains and the effectiveness of eight forms of collaborative planning processes, Petersen, Ragatz and Monczka found that trust impacts the planning effectiveness, affecting five of the eight processes (Petersen, Ragatz and Monczka 2005).

2.3. *Win-Lose Versus Win-Win*

The benefits of closer network cooperation and realities of business in the global economy of the twenty-first century imply that most companies ought to be practicing this now. The reality, however, is that "most companies implement supply chain integration only in a limited and fragmented manner, with the result being that the expected benefits are unable to be realized" (Tai, Wang and Wang 2007).

There are many reasons companies fail to follow through on supply chain integration and collaboration, including inherent complexities in managing processes across multiple firms, lingering "adversarial" attitudes seeking to gain competitive conditions, and a myopic focus on short term cost saving measures at the expense of long-term value creation (Grover, Lau and Sharma 2008) (Sahay 2003) (Nambisan and Sawhney 2008). An underlying problem leading to minimal supply chain integration stems from a tendency for companies to view the value chain in terms of a "zero-sum" game. They frame a "gain" on the part of their channel partners as a "loss" on theirs, failing to realize that innovation and collaboration in the value chain over the long term can bring mutually beneficial results. In a study including interviews of over 100 supply chain partnerships, Myers and Cheung note "many supply chain members had an aversion to participating in activities that could provide more benefit to partners than to their own company. Increasingly, supply chain partners see themselves as competing among themselves for revenue" (Myers and Cheung 2008).

2.4. *Choosing to "Cheat"*

Why can't most companies dedicated to creating a supply chain enterprise always achieve an effective partnership with their suppliers? Simply stated, because people and the companies they work for often have strong senses of self-interest and find it difficult to trust others. Mistrust (or at least cautious trust) is a defense against risking loss in a social (or in this case, business) interaction. This is not meant to imply that all people or companies are choosing to be dishonest. They often have the best of intentions in mind, and fully intend to be honorable. This is reflected in most firms' corporate values statements, which often espouse integrity, honesty, and

trustworthiness. Peoples' actions at either end of these traits are usually visible and apparent; the problem arises in the "gray area" situations. What one company considers dishonest, its partners may not.

Beyond companies' intentions to be honest, most people would value being trustworthy and being recognized as so. So if people and companies commonly hold these values, why do they so frequently fail to live up to them? In his bestselling book *Predictably Irrational*, behavioral economist Dan Ariely provides an insight:

> "We care about honesty and want to be honest. The problem is that our internal honestly monitor is active only when contemplating big transgressions... For the little transgressions... we don't even consider how these actions would reflect on our honesty and so our superego stays asleep." (Ariely, Predictably Irrational: The Hidden Forces That Shape Our Decisions 2008)

The unfortunate truth is that for many companies, market forces tend to exert more influence on their short-term actions than long-term thinking. Many fail to see the second and third order consequences of some of their decisions. In the case of central firms within a value chain, they often have the power to exert significant influence over their partners. This provides the opportunity to take actions that only benefit themselves. The problem that many do not realize though, is that "when companies systematically exploit their advantage, their victims ultimately seek ways to resist" (Kumar 1996). As previously described, if companies were only to do business with others for a single transaction, there would be no risk of retaliation from channel partners. How often is this that the case though? Under a more realistic assumption of repeated interactions between two parties, it is useful to look at the situation from a different perspective.

2.5. SCM THROUGH THE LENS OF GAME THEORY

Game theory is a discipline of applied mathematics often used in the social sciences and economics. It is a methodology to evaluate strategic choices when making decisions that interact with the choices of others. Game theory does not, however, provide a tool in which we can feed an input and expect a clear, empirical answer. Rather, it is a useful tool for constructing models and imposing logical discipline on how we frame our decision-making in different scenarios; "It is a guide to decision making that gives us pointers to what is really going on" (Fisher 2008).

The buyer-supplier relationship often faced in business is reminiscent of the Prisoners' Dilemma logic trap of game theory. This logic trap describes the scenario where two parties, each acting in

their own best interest, end up both faring worse than if they had cooperated to act in their collective best interest.

The classic example, from which the name is derived, describes when two suspects are arrested by the police. The police believe the suspects are guilty of a larger crime, but do not have enough evidence to get a conviction. There is, however, enough evidence to convict them of a lesser crime. The police separate the suspects to interrogate them, telling each suspect that they know what happened. If the suspect just explains all the details, the police explain, the suspect will receive a greatly reduced sentence, while the other will receive a harsh sentence. If both suspects confess, however, they will not be able to negotiate the sentence down as much. Clearly it is in both suspects' collective best interest to keep their mouths shut and accept the shorter sentence. However they are separated, and each probably fearful that the other may testify against them (in game theory parlance, this is known as *defecting* or *cheating*). For each of them individually, they become better off to testify, regardless of what the other does, as depicted in the diagram below (Dixit, Skeath and Reiley 2009).

		SUSPECT 2	
		Confess (Defect)	*Deny (Cooperate)*
SUSPECT 1	Confess (Defect)	10 yr, *10 yr*	1 yr, *25 yr*
	Deny (Cooperate)	25 yr, *1 yr*	3 yr, *3 yr*

Figure 1: Prisoners' Dilemma Payoff Matrix

This is known as their *dominant strategy*. Because testifying against the other is the individual dominant strategy for both, they will both defect and cut a deal to testify. However their testimony is less valuable to the police if they both do so, and therefore will both go to jail for 10 years. If they had been able to cooperate and could trust each other, they could have decided to both keep quiet and take the shorter sentence. Their dominant strategies have moved them into a suboptimal *Nash Equilibrium*, named after Nobel Prize winning mathematician and economist John Forbes Nash. The Nash Equilibrium is a position where both parties are getting the best solution possible with their opponent playing their dominant strategy. To improve their position, they must cooperate and work together to change the payoff of the game (Dixit, Skeath and Reiley 2009).

2.6. *PRISONERS' DILEMMA IN THE VALUE CHAIN*

So how does the Prisoners' Dilemma apply to firms working together in a value chain? Imagine two companies only doing business with each other for a single transaction. After coming to agreement on terms of the deal, each party can either abide by the terms (*cooperate*) or choose to disregard them (*defect/cheat*). The benefits (or *payoff*) of cooperating are highest for both, however there are also costs involved. If one company decides to cheat and not follow the terms of the agreement, they lower their transactional costs but maintain their benefit, thus raising their payoff. However the other party also has the same incentive to cheat to raise their own payoff. Depending on the specific payoffs involved in our example, we may again arrive at a suboptimal Nash equilibrium:

		FIRM 2	
		Defect	*Cooperate*
FIRM 1	Defect	\$100, *\$100*	\$1000, *\$0*
	Cooperate	\$0, *\$1000*	\$500, *\$500*

Figure 2: Prisoners' Dilemma Payoff Matrix in the Value Chain

If the firms had cooperated, they would have each received a good payoff. However in seeking to get a higher payoff and/or avoid "losing" if the other party cheated, they are each driven to cheat. Cheating in the sense of the value chain can be, for example, a buyer not paying their invoices on time or in full, cancelling contracts and taking business to a cheaper competitor, or not equally sharing profits. In the supplier's case, cheating can take the form of less prompt deliveries, lower quality control, or less volume discounts. For buying firms with negotiating power, this is especially important to realize, because "any attempt to reduce [the supplier's profit] through an uncooperative practice... will only encourage the supplier to take retaliatory action" (Axelrod 1984) (Macaulay 1963).

Now expand the above example to that of two companies doing repeated business together. The strategic situation now becomes an iterated Prisoners' Dilemma. When there are repeated interactions, firms have more of an incentive to not cheat, because their past history of participation is known to their counterparts. This will affect decisions on each subsequent interaction as whether or not to cooperate or cheat. Axelrod notes:

> "There is an important contrast between a zero-sum game like chess and a non-zero-sum game like the iterated Prisoner's Dilemma... Keeping one's intentions hidden is useful in a zero-sum setting... but in a non-zero-sum setting it does not always pay... In the iterated Prisoner's Dilemma, you benefit from the other player's cooperation. The trick is to encourage that cooperation... Words can help here, but as everyone knows, actions speak louder than words" (Axelrod 1984).

Viewing a repeated business interaction in terms of game theory shows the importance for companies to build trust. It will discourage future cheating by their value chain partners. Otherwise the relationship can move towards the suboptimal Nash equilibrium where both parties lose. Companies can move to this through different "showcase" experiments, conducting more frequent and "riskier" interactions. Risk goes hand in hand with trust: "[One must] give someone the chance to cheat in order to learn to trust them" (Montague 2006). Game theory then cues us towards the obvious conclusion: "If we could find ways to trust each other, we could then find win-win solutions to many of our most serious problems" (Fisher 2008).

2.7. Humans and Our Irrationality

The game theoretic lens makes it seem so simple to realize that if business partners can learn to trust each other, they will end up better off. This realization should appeal to people's rationality – that they can trust each other and both succeed. The problem is that most people often don't act rationally. This can be seen everywhere from people's personal decisions, to those having an impact on global trade and finance. Recently behavioral economics, a new take on traditional economic theory, has gained significant prominence, especially amid rampant irrational decisions that helped lead to the global recession beginning in 2007 (Leaders: What Went Wrong With Economics 2009). Research among behavioral economists has consistently shown "that we are emotional, myopic, and easily confused and distracted" (Ariely, The End of Rational Economics 2009).

The synthesis of these traits, predilections for opportunism and irrational decision-making, potentially poses some serious problems that business leaders need to consider. An executive does not need to worry about an employee in their company making an irrational choice to exploit suppliers. If done, that could lead to both retaliation and a decrease in their suppliers' level of trust in the company. As a safeguard against this threat, many companies have some form of values and professional ethics they espouse, as well as business procedures to be followed. When that isn't

enough, a strong business leader places emphasis on the matter and requires "leader involvement." But does a stronger emphasis on "doing the right thing" ensure that people will?

The fact is that the human brain is both hardwired to be mistrusting as well as to act irrational. Current research has shown that there is a biological link to trust (Fisher 2008). In all facets of life, species are placed in scenarios that test their trust in others. Because mistrust is a risk dominant strategy while trust is payoff dominant, "in simple evolutionary terms... mistrust should always predominate." Evolutionary biologists have long recognized that natural selection has shown those species with the most highly developed sense of mistrust are the ones most likely to survive and pass those traits on to their offspring (Fisher 2008).

The pessimist can see the correlation in human society. People who are overly trusting are taken advantage of. Unfortunately those who are unrelentingly mistrustful drive the vicious cycle of mistrust, retaliation, and opportunism that businesses ought to be seeking to avoid. When placed in interpersonal and inter-organizational relationships, can people rely upon their ability to judge the trustworthiness of others? Unfortunately this may not be a sound method. Research has shown that "intuition can let us down badly, as shown by the fact that so many of us still fall for confidence tricks" (Fisher 2008).

People's actions when under stress heighten the concern of this issue for business leaders. Most people believe that they can control themselves and "keep cool" under pressure, however research indicates otherwise. Behavioral economists have shown through experimentation that in emotional situations, "even the most brilliant and rational person... seems to be absolutely and completely divorced from the person he thought he was" (Ariely, Predictably Irrational: The Hidden Forces That Shape Our Decisions 2008). Considering the stress often involved with supply chain management, executives ought to be concerned how their people will act when dealing with suppliers. A single act alone can be detrimental to a relationship with a supplier. An employee's actions, as differing from the company's intent as they may be, nonetheless will reflect upon the entire company in the supplier's eyes. First impressions are strong, and the damage done by a single opportunistic act may take years to recover from. In essence, these first impressions create "anchors" in the suppliers' minds that then guide all their future impressions of their customers (Ariely, Predictably Irrational: The Hidden Forces That Shape Our Decisions 2008).

2.8. Overcoming Our Shortcomings

If our own DNA is going to predispose us to being mistrustful and acting irrational, where are we left? Fortunately, the situation is not as bleak as it may seem. Although we are predisposed to

mistrust and to be cautious, humans also *want* to trust others and to be trusted by others. Exciting new research in computational neuroscience has proven, using brain imaging experiments, that trust can gain value in our brains as a neural "reward." Montague highlights how such experimentation has shown the subtly of trust; that it is "a complex yet instinctual emotion." Because of the instinct to value trust, it can serve as a mechanism that allows efficient social interactions despite the risk of loss (Montague 2006).

It is clear that all companies in long-term value chain relationships can benefit from greater trust and cooperation. Peterson, Ragatz, and Monczka underscore the need to build a relationship around trust with ones suppliers before they can enjoy real success in collaborative planning (Petersen, Ragatz and Monczka 2005). An employee in Raytheon's Integrated Supply Chain summarized the importance of developing trust in the buyer-supplier relationship:

> "An atmosphere of trust allows for many opportunities. With this type of relationship one can accomplish successes due to production acceleration and shortages, emergency engineering changes, and much more. The best negotiations always result when the deal is mutually beneficial to all parties."

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3. MODELING TRUST IN THE BUYER-SUPPLIER RELATIONSHIP

3.1. *OVERVIEW*

In this chapter the author details the development of a conceptual model of trust in the buyer-supplier relationship. Using data from an extensive survey of Raytheon suppliers, the author formulates and validates specific hypotheses about the effect of certain actions in increasing or decreasing a company's tendency to view their channel partner as trustworthy. Although conceptual, this model forms the basis of the development of a framework to help guide supplier partnering and information sharing initiatives, which will be detailed in Chapter 4.

3.2. *DISCUSSION OF THE MODEL CONSTRUCT*

The first step in moving towards an IT-enabled process of trust-building is to describe how trust factors into the relationship between a buyer and their suppliers. To aid in understanding such abstract concepts, the author turned to a method known as structural equation modeling (SEM). SEM is an analytical method, similar to multiple regression, that allows researchers to investigate both correlation and causation between both observable and unobservable factors. The most important step of SEM is clearly defining a theoretical model based upon research, expert knowledge, and scientific hypotheses. Good structural modeling of a "bad" model will produce ambiguous and possibly misguided conclusions (Kline 2005).

The author's supposition of a trust model began with a previous study by Sanders, in which a linkage was established between firms' IT alignment, integration, and performance measures. The conclusions of Sanders's study are shown in Figure 3 below (Sanders 2005).

The author began by expanding upon the causal link from firm alignment to integration, questioning what factors moderate the desire for suppliers to integrate with their customers. The underlying hypothesis of the model is that a supplier's perception of their buyer's transparency and accountability – trust in their buyer – has a positive impact both on their own desire to be considered trustworthy, as well as their desire to integrate with buyers. Simple integration, however, does not mean companies truly work together. Because of this, the author chose to investigate the linkage between firms' integration – the foundation for them to work together – and their collaboration –the actual manifestation of them working together. The author's theoretical model is shown in Figure 4.

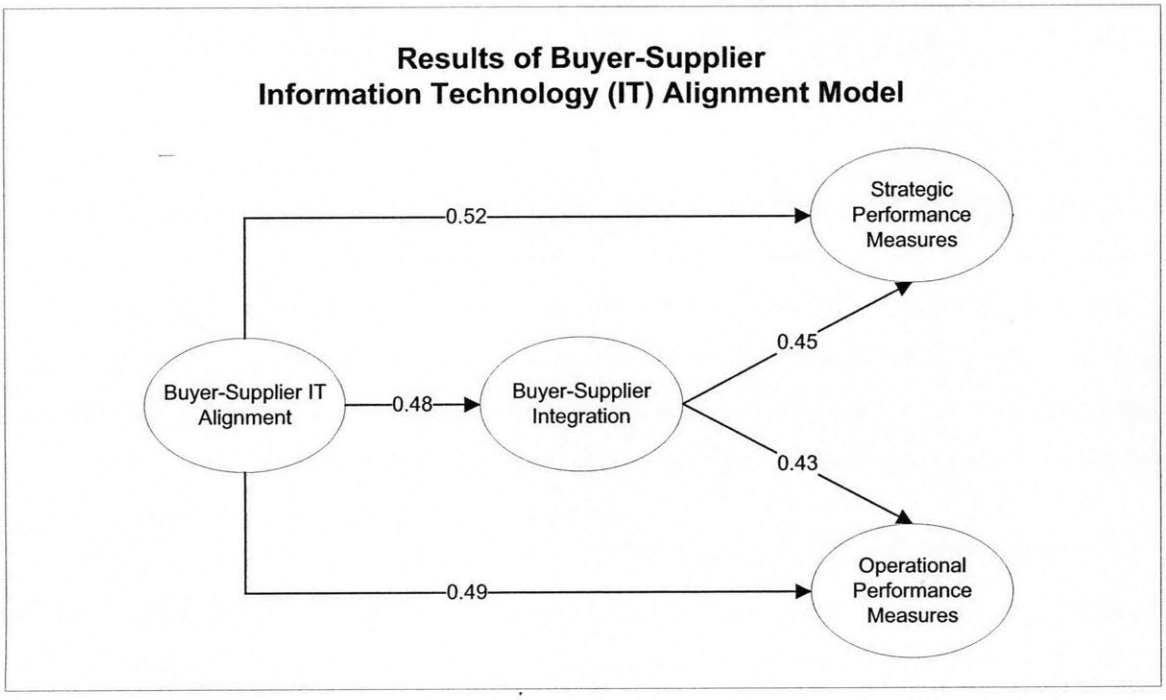

Figure 3: Sanders's IT Alignment Model

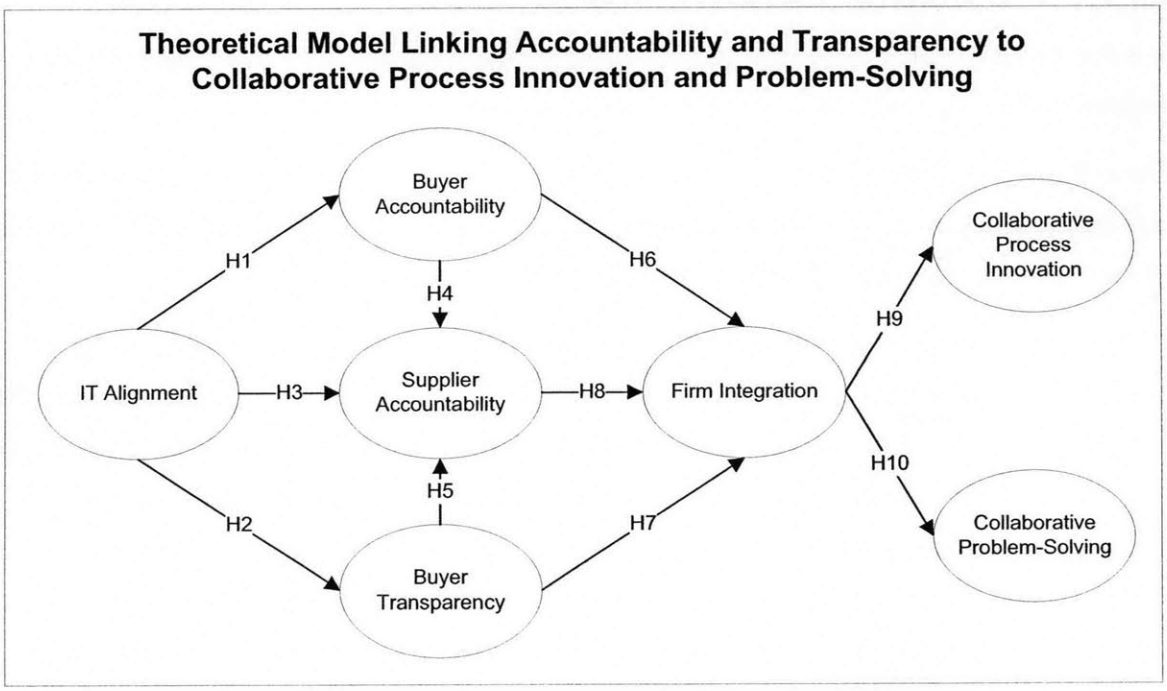

Figure 4: Theoretical Model

3.3. *Model Hypotheses*

The first set of hypotheses concerns how the alignment – through similarity, orientation, and coherence – of information technology (IT) assets between a buyer and supplier affects the supplier's perception of each party's accountability and transparency. The model assumes that companies, similar to individuals, like and prefer those that are similar to themselves (Cialdini 1993). Firms that operate with varying levels of IT in their businesses might not be as open, partly because they do not "understand" each other. With IT, a certain underlying amount of IT assets between companies need to be aligned because of the tacit knowledge their use develops. For example, a large, technically advanced company that uses a great degree of IT in its operations is not aligned well with a supplier that is a small, family owned business who conducts most bookkeeping on paper and shares a single computer. The severe differences between these companies and the difference in their levels of knowledge may work to create a veil of secrecy – real or perceived – that hinders the supplier's trust in their buyer. Contrast this first example with the case of a supplier who also uses IT throughout their business, perhaps even some of the same commercial applications as their buyer. This company is much more aligned and able to "plug and play" their operations into their buyer's, and is inherently more apt to understand and trust them. Consequently, the first three hypotheses of the model are:

> **H1:** IT alignment between a buyer and supplier has a direct and positive impact on a supplier's perception of their buyer's accountability.
>
> **H2:** IT alignment between a buyer and supplier has a direct and positive impact on a supplier's perception of their buyer's transparency.
>
> **H3:** IT alignment between a buyer and supplier has a direct and positive impact on a supplier's decision to be accountable to their buyer.

The second set of hypotheses underlying the model concerns how the supplier's perception of their buyer's accountability and transparency affects their motivation to be accountable in return. Game theory contributes to these hypotheses through the idea of a "tit-for-tat" strategy. If a supplier feels their buyer is trustworthy, they feel they can return the same; however if the buyer does not display trustworthiness, the supplier will have less desire to do so themselves. Axelrod notes that to sustain cooperation it is necessary to recognize others' past interactions, and to remember the relevant features of those interactions (Axelrod 1984). This is reflected when a supplier recognizes openness of their buyer on past interactions, and thus decides to cooperate and return that openness. The game theorist's idea to promote cooperation is to offer credible

commitment, "which involves each party demonstrating its commitment in a way that gives the others good reason to believe in it" (Fisher 2008). Companies can display credible commitment "by showing someone else that [they] are willing to trust them, even when that trust has not been earned. Such an action can often initiate a cycle of trust by motivating others to show trust in return" (Fisher 2008). Companies exposing information are trusting that others will not exploit it for gain. Therefore the next two hypotheses of the model are:

> **H4:** A supplier's perception of their buyer's accountability has a direct and positive impact on their decision to be accountable to their buyer.
>
> **H5:** A supplier's perception of their buyer's transparency has a direct and positive impact on their decision to be accountable to their buyer.

The third set of hypotheses concerns how a supplier's perception of themselves and their buyers influences them to integrate with their buyer. Even while operating in a relationship with a lack of trust, companies can still effectively do business together. Significant gains, however, start to be realized when the companies work together cooperatively. Companies will be much more willing to engage in long-term, cooperative, integrated business processes with those that they trust. If they also feel that they are accountable for their own actions, it heightens their sense of commitment to the relationship and leads them to integrate. This integration is possible because as both firms become accountable and transparent to each other, they are in effect changing the payoffs of the Prisoner's Dilemma by "[making] the long-term incentive for mutual cooperation greater than the short-term incentive for defection" (Axelrod 1984). Accountability and transparency thus form the bridge that links IT alignment to integration. Multiple studies have shown that IT leads to closer cooperative relationships, and through such integrated relationships, leads to performance increases for both firms (Sanders 2005) (Subramani 2004). This relationship is detailed in the next three hypotheses of the model:

> **H6:** A supplier's perception of their buyer's accountability has a direct and positive impact on their decision to integrate with their buyer.
>
> **H7:** A supplier's perception of their buyer's transparency has a direct and positive impact on their decision to integrate with their buyer.
>
> **H8:** A supplier's perception of their own accountability has a direct and positive impact on their decision to integrate with their buyer.

The final set of hypotheses concerns how integration between firms – through incorporating their business and IT processes together – leads them to collaboratively engage in process innovations and problem-solving. Integration between firms facilitates better flow of information, reduced ambiguity of actions, and more timely communication, which allows companies to collaborate together. Sriram and Stump determined empirically that "it is not IT investments installed... which drive performance improvements, but the resultant improvements in communications patterns and relationship quality" (Sriram and Stump 2004). Ultimately it is the people in organizations doing this collaboration, but supported by IT: "supply chain integration involves collaboration and is a result of human interactions that can only be supported by IT, but not replaced" (Sanders 2005). This leader involvement and proactive action leads to the best collaborative gains, and is reflected in the final two model hypotheses:

> **H9:** Firm integration between a buyer and supplier has a direct and positive impact on a supplier's decision to collaborate on process innovations with their buyer.
>
> **H10:** Firm integration between a buyer and supplier has a direct and positive impact on a supplier's decision to collaborate on problem-solving with their buyer.

3.4. Survey Methodology and Design

To gather data to test the theoretical model and learn more about the relationship of IT, trust, and collaboration in a value chain, the author conducted a survey of Raytheon's suppliers (hereafter referenced as the "external survey"). Data derived from the survey was used with the theoretical model to form and evaluate a structural equation model (SEM) to prove or disprove the individual hypotheses. A similar survey was also developed and administered to employees within Raytheon's Integrated Supply Chain (ISC) to determine any "gaps" in thinking between buyers and suppliers (hereafter referenced as the "internal survey").

3.4.1. Measures to Test the Model Construct

Because the factors used in the hypothetical model are unobservable and immeasurable, the author developed survey questions creating three measures per factor. To maintain consistency, factors to measure the degree of alignment and similarity in IT applications between a supplier and their primary buyer, and firm integration, use the same scale items as Sanders's previous study.

Table 1: Summary of Construct Measures

FACTOR	MEASURES
IT Alignment (AL)	1. Similarity in applications for transaction processing 2. Similarity in applications used for operations processes 3. Similarity in applications for communications
Firm Integration (IN)	1. Partnering between firms 2. Utilization of cross-functional teams 3. Engagement in strategic collaborative planning
Buyer Transparency (BT)	1. Disclosure about firms' position in the value chain 2. Sharing of business strategy with suppliers 3. Cost/accounting focus on creating shared value
Buyer Accountability (BA)	1. Allowance of fair profit for suppliers 2. Accurate planning information provided to suppliers 3. Accurate financial information provided to suppliers
Supplier Accountability (SA)	1. Adherence to meeting service level agreements 2. Information provided on cost reduction efforts 3. Information provided on quality improvements
Process Innovation (PI)	1. Continuous improvement projects collaboratively engaged in 2. Involvement of suppliers in product changes and new product development 3. Involvement of suppliers in business process changes
Problem-Solving (PS)	1. Collaboratively developed metrics 2. Acknowledged and resolution of performance deviations 3. Cooperative response to disruptions in the supply chain

Factor 1, "IT Alignment (AL)," measures the degree of IT alignment and is measured by three scale items: how similar applications for transaction processing are, how similar applications used for operations processes are, and how similar applications for communications are (Sanders 2005).

Factor 2, "Firm Integration (IN)," measures the degree of integration between buyer and supplier firms, and is measured by three scale items: partnering between firms, utilizing cross-functional teams, and firms' engaging in strategic collaborative planning (Sanders 2005).

Factor 3, "Buyer Transparency (BT)," measures the degree to which Raytheon's business is transparent to its suppliers, compared to the suppliers' other customers. Lamming notes that "two-way sharing of sensitive information in the pursuit of new value creation heightens the richness of the knowledge environment between customer and supplier." Furthermore, a transparent relationship involves full disclosure of value creation, a mutual understanding of strategy, and a focus on creating value through the relationship (Lamming, et al. 2001). Thus Factor 3 is measured by three scale items: how much Raytheon discloses about its portion of the value chain, how much they share their business strategy with suppliers, and how much their cost/accounting focus is on creating shared value.

Factor 4, "Buyer Accountability (BA)," measures the degree to which Raytheon is accountable to its suppliers, compared with the suppliers' other customers. Slobodow, Abdullah, and Babuschak emphasize the importance of dual accountability and a need for firms to have "a commitment to meet suppliers halfway." Their "Two Way Scorecard" highlights items of buyer and supplier accountability, and is reflected in the scale items measuring Factor 4: the extent to which Raytheon allows their suppliers to make a fair profit, how much they provide accurate planning information to their suppliers, and how much they provide accurate financial information to their suppliers (Slobodow, Abdullah and Babuschak 2008).

Factor 5, "Supplier Accountability (SA)," measures the degree to which Raytheon's suppliers are accountable to them, compared to their other customers. The "Two Way Scorecard" also highlights comparable metrics to measure accountability on the part of the supplier. Thus, Factor 5 is measured by three scale items: the extent to which Raytheon's suppliers informs them of the ability to meet service level agreements, the amount of information provided on cost reduction efforts, and the amount of information provided concerning improving quality (Slobodow, Abdullah and Babuschak 2008).

Factor 6, "Process Innovation (PI)," measures the degree of collaborative process innovation between Raytheon and its suppliers. Ferrari and Parker note that "global supply chains are all about networks, about companies putting their processes together." As such, *collaborative* process innovation concerns improvement activities undertaken by many firms being done jointly with their suppliers. Factor 6 is measured by three scale items: the amount of continuous improvement projects Raytheon and its suppliers collaboratively engage in, the extent to which Raytheon involves its suppliers in major product changes and new product development, and the extent to

which Raytheon and its suppliers coordinate for major business process changes (Ferrari and Parker 2006).

Factor 7, "Problem-Solving (PS)," measures the degree of collaborative problem-solving between Raytheon and its suppliers. Problem-solving in the value chain centers around firms' ability to "sense and respond to any supply chain disruptions and marshal supply chain resources to overcome shortages and/or excesses" (Ferrari and Parker 2006). Factor 7 is measured by three scale items: how much Raytheon and their suppliers collaboratively develop metrics, the extent to which deviations from performance measures are acknowledged and resolved together, and the degree to which Raytheon and its suppliers work together to respond to disruptions in the supply chain (Landeros, Reck and Plank 1995) (Ferrari and Parker 2006).

3.4.2. PRETESTING

The survey tool was implemented in an electronic format using the website SurveyMonkey.[1] The advantages of an online electronic survey tool include increased ease of data collection, easier and faster replies for respondents, and the ability to quickly change the survey tool. The initial survey tool went through several methods of pretesting to ensure it accurately measured desired indicators, as well as increased reliability and validity of the respondents' answers.

The survey was first evaluated using the online tool Question Understanding Aid (QUAID), which assists researchers in determining potential problems "with question comprehension, including unfamiliar technical terms, vague or imprecise relative terms, vague or ambiguous noun phrases, complex syntax, and working memory overload [for respondents]." (Graesser, et al. 2006) The results of QUAID led to several of the questions being reworded to reduce ambiguity and standardize definitions of terms.

Next, the survey tool was presented to a group of the author's MIT Sloan classmates. Fifteen students each read through the survey tool and indicated areas where questions caused confusion or were difficult to answer. The survey was then administered electronically to a small group of employees of a Raytheon supplier. The author was in the room and asked questions to gauge the respondents' level of question comprehension. This method is known as cognitive pretesting, and ensured questions could be consistently understood and answered by respondents (Kline 2005).

The final step in pretesting was to administer it to a small group of Raytheon suppliers. The author randomly selected 100 respondents from the group of non-selectees for the final survey. An

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[1] http://www.surveymonkey.com

[2] CDAR = contract dollars at risk; APC = annual purchase commitments; Q = quality; and D = delivery

invitation was sent electronically with a link to the survey pretest, which was presented exactly as the final version, however also containing a section in each group of questions for respondents to make any comments pertaining to how the author might increase the ease of completing the survey. 22 of the 100 suppliers receiving this invitation responded, and as a result several final changes were made to the survey tool.

3.4.3. Sample Selection

Sample selection was important to conducting a meaningful analysis. First and foremost, ensuring adequate data to conduct the structural equation modeling was paramount. Because SEM is a large-sample technique and similar studies have yielded varying degrees of response, it was necessary to reach out to a large base of suppliers (Kline 2005) (Fowler 2009) (Sanders 2005). Different methods of SEM require different sample sizes, but in general sample sizes over 200 are considered large, while samples between 100 and 200 are considered medium. To reasonably expect enough responses for a medium to large sample, the targeted respondent list was set at 1,000 companies (Kline 2005). The author anticipated a response rate of approximately 20%, which seemed reasonable to ensure enough data for an SEM analysis.

The author generated a list of potential respondents from a complete list of Raytheon IDS suppliers which numbered over 3,000. The list was shortened by eliminating all companies that had not fulfilled any contracts within the previous 12 months and companies with transactions with Raytheon totaling less than $1,000, bringing the total to fewer than 2,000. It was then further shortened by eliminating international suppliers. The exclusion of the small number of international suppliers (only 22) did not stand to drastically alter the results, and avoided the increased logistical difficulties in delivering the survey tool internationally. The final list of potential respondents numbered 1,847.

To ensure a representative sample of company sizes, the full list was stratified by the amount of annual business they conduct with Raytheon (Fowler 2009). A number of suppliers from each stratified group proportional to the groups' size in the overall population were selected. Individual respondent companies were selected by being assigned a random number and selecting the first suppliers by random number up to the overall size required for each stratified group.

3.4.4. Response Rate & Nonresponse Bias

Failure to collect data from a truly representative sample of the population increases the likelihood of error in the data and subsequent analysis. It is necessary to structure the data

gathering process to ensure a suitable amount of data is collected, and also to analyze any adverse affects from failing to do so.

In order to maximize the response rate of the survey tool, the author made significant efforts to ensure the survey reached the intended respondents, and to encourage those respondents to complete the survey. To deliver the external survey to respondents who were qualified to answer it, suppliers' mailing addresses were collected from Raytheon's Enterprise Supplier Data database. Letters were personally addressed to the highest ranking representative for whom information was available. Letters were sent in Raytheon envelopes to reduce the chance they might be discarded as junk mail. For the internal survey, the author introduced the survey tool to the Integrated Supply Chain Supplier Partnering staff prior to emailing a request to employees to complete the survey. The email was sent from a Raytheon domain, decreasing the chances that emails would be lost to spam filters and increasing the author's credibility with Raytheon's employees.

Most importantly, the author made repeated contact with nonrespondents using a modified version of Dillman's design method (Fowler 2009) (Dillman 2009). For the external survey, initial cover letters and requests were mailed, followed by a second mailing three weeks later, which included a friendly reminder and instructions on how to access the survey in case the first letter had been discarded. Two similar reminders were made via email for the internal survey.

To encourage maximum participation by suppliers for the external survey, the cover letter was sent on MIT letterhead. The author's intent was to assuage any concerns the suppliers might have that Raytheon was "checking up" on them, and instead highlight the main purpose of the survey for academic research. The URL for the survey tool was long, so to increase the ease for respondents receiving the printed letter, the author instead directed them to a research blog containing a link to the survey. Respondents for the internal survey received an email which contained a direct link to the survey tool. Both surveys included indications to the respondents from the author that all responses were completely voluntary and anonymous.

For the internal survey, of the 300 request emails sent, 33 were returned as undeliverable and 124 responses were received. Thirteen were discarded due to incomplete data and 33 were discarded due to the respondents' lack of subject knowledge (e.g. the respondents were administrative assistants), yielding an effective response rate of 29.2%.

For the external survey, of the 1,000 letters mailed, 16 were returned as undeliverable and 148 responses were received. Nine responses with limited item nonresponse (e.g. answered 17 or more of 21 questions) were completed through a method known as imputation, where the responses for

missing data were derived by averaging the response for that question from all other respondents who answered the same on other questions (Fowler 2009). 31 others were discarded due to severely incomplete data, yielding an effective response rate of 11.9%. The response rate for the external survey was lower than the author hoped to achieve, however falls in the range of similar results for internet based surveys, which are relatively new and can produce widely varying results (Fowler 2009).

Checking for nonresponse bias involved extrapolating data from the survey respondents. The most common form of extrapolation is based on the assumption that respondents who respond later in a survey and those who require more prompting to complete the survey are similar to nonrespondents. It then becomes possible to evaluate any statistical differences between respondents and "nonrespondents" (Armstrong and Overton 1977).

Independent sample t-tests were used to compare the different rated factors between early and late respondents and determine if there were any statistically significant differences. For the external survey no evidence of nonresponse bias was present. For the internal survey, the only factor possibly indicating nonresponse bias was Buyer Accountability (BA). Independent sample t-tests were subsequently performed on each of the three measures of BA and found that BA1 and BA3 might have suffered from nonresponse bias. Because BA2 and the rest of the measured factors showed no signs of nonresponse bias, the author chose to keep the data as it did not appear to taint the overall data collection.

3.5. *Survey Data Analysis*

3.5.1. *Description of Analysis Tools*

Data was prepared for structural equation modeling using two software applications. JMP®8 is the latest version of the JMP® Statistical Discovery Software package produced by SAS. JMP® allows engineers, scientists, and researchers to conduct statistical analyses and interactively explore, visualize and better understand their data. (SAS Institute Inc. 2008)

Mx is a public domain structural equation modeling (SEM) software package freely available from Virginia Commonwealth University. Mx is comparable to commercial SEM software packages such as LISREL, LISCOMP, EQS, SEPATH, AMOS and CALIS, and allows data analysis through a graphical user interface (Neale, et al. 2004).

3.5.2. *Reliability*

Before using survey data to conduct the structural equation modeling, it was necessary to ensure the data was reliable and did not suffer from random measurement error. Error could be introduced by any number of reasons: the respondent did not click the answer they intended, the respondent randomly selected answers, etc. Because of the opportunity for error, the model construct used three measures to assess each factor. It is presumable that a respondent's answers for each of the three measures of a given factor should be somewhat similar. The most common measure of internal reliability is Cronbach's coefficient α which measures "the degree to which responses are consistent across the items within a single measure." Although coefficient levels may vary between different studies, in general "reliability coefficients around .90 are considered 'excellent,' [and] values around .80 are 'very good'" (Kline 2005).

The survey data for the external survey was analyzed in JMP® to determine Cronbach's α for each measure. Measures for six of the seven factors were found to contain very good or excellent internal reliability. The coefficient α for Buyer Accountability (BA) was 0.74, which is still considered acceptable.

For the internal survey, measures for five of the seven factors were found to have very good or excellent Cronbach α scores. Cronbach α scores for the factors IT Alignment (AL) and Buyer Accountability (BA) were 0.76 and 0.73, respectively, which are still considered acceptable.

Table 2: Cronbach Coefficient Reliability Measures

Factor	Internal Survey Cronbach α	External Survey Cronbach α
IT Alignment (AL)	0.7584	0.8468
Firm Integration (IN)	0.8718	0.9030
Buyer Transparency (BT)	0.8402	0.9016
Buyer Accountability (BA)	0.7257	0.7436
Supplier Accountability (SA)	0.9003	0.8996
Process Innovation (PI)	0.8381	0.9265
Problem-Solving (PS)	0.9045	0.9275

3.5.3. *Validity*

In addition to ensuring reliability of the data, it was necessary to confirm the data was valid and measured what was intended. Because the factors in the hypothetical model construct are abstract and not directly observable, the author determined if the observed measures actually reflected upon the factors they were intended to. A common method for determining validity is confirmatory factor analysis (CFA), including assessing both convergent and discriminant validity, which involves evaluating the measures against each other. "A set of variables presumed to measure the same construct shows convergent validity if their intercorrelations are at least moderate in magnitude. In contrast, a set of variables presumed to measure different constructs shows discriminant validity if their intercorrelations are not too high" (Kline 2005).

Confirmatory factor analysis of the 21 indicators was performed in Mx (see Appendix C: Model Analysis in Mx). In evaluating convergent validity, 20 of the 21 indicators were found to have significant loading on their related factors, indicating they are accurate measures of the factor. The indicator BA1 had a low factor loading of 0.39 on its associated factor, Buyer Accountability (BA). This indicates that BA1 might not be an accurate measure of BA. It was accordingly removed, leaving BA2 and BA3 as the remaining two indicators for Buyer Accountability (BA).

In evaluating discriminant validity, intercorrelation between the factors Buyer Accountability (BA) and Buyer Transparency (BT) was found to be moderately high at 0.82, while the intercorrelation between Process Innovation (PI) and Problem-Solving (PS) was found to be 0.84. All other intercorrelations were not moderate in magnitude. As a result, the factors BA and BT were combined into one common factor, Buyer Trustworthiness (BT). The factors PI and PS were combined into one common factor, Collaboration (CO). Additionally, to maintain consistency in naming conventions, Supplier Accountability (SA) was renamed Supplier Trustworthiness (ST).

A second CFA (shown in Appendix C: Model Analysis in Mx) was performed on the revised indicators and factors, showing good convergent and discriminant validity for the revised model.

3.5.4. *Revised Reliability Measures*

After revising the model based on the confirmatory factor analysis, reliability of the measures was again verified by recalculating Cronbach coefficient α for the revised factors. All of the revised factors were found to have very good or excellent internal reliability.

Table 3: Revised Cronbach Coefficient Reliability Measures

Factor	External Survey Cronbach α
IT Alignment (AL)	0.8468
Firm Integration (IN)	0.9030
Buyer Trustworthiness (BT)	0.9032
Supplier Trustworthiness (ST)	0.8996
Collaboration (CO)	0.9419

3.6. Revised Model Hypotheses

Revision of the factors following confirmatory factor analysis necessitated a modification of the original theoretical model and associated hypotheses:

H1/H2: IT alignment between a buyer and supplier has a direct and positive impact on a supplier's perception of their buyer's trustworthiness.

H3: IT alignment between a buyer and supplier has a direct and positive impact on a supplier's decision to be trustworthy to their buyer.

H4/H5: A supplier's perception of their buyer's trustworthiness has a direct and positive impact on their decision to be trustworthy to their buyer.

H6/H7: A supplier's perception of their buyer's trustworthiness has a direct and positive impact on their decision to integrate with their buyer.

H8: A supplier's perception of their own trustworthiness has a direct and positive impact on their decision to integrate with their buyer.

H9/H10: Firm integration between a buyer and supplier has a direct and positive impact on a supplier's decision to engage in collaborative process innovation and problem-solving with their buyer.

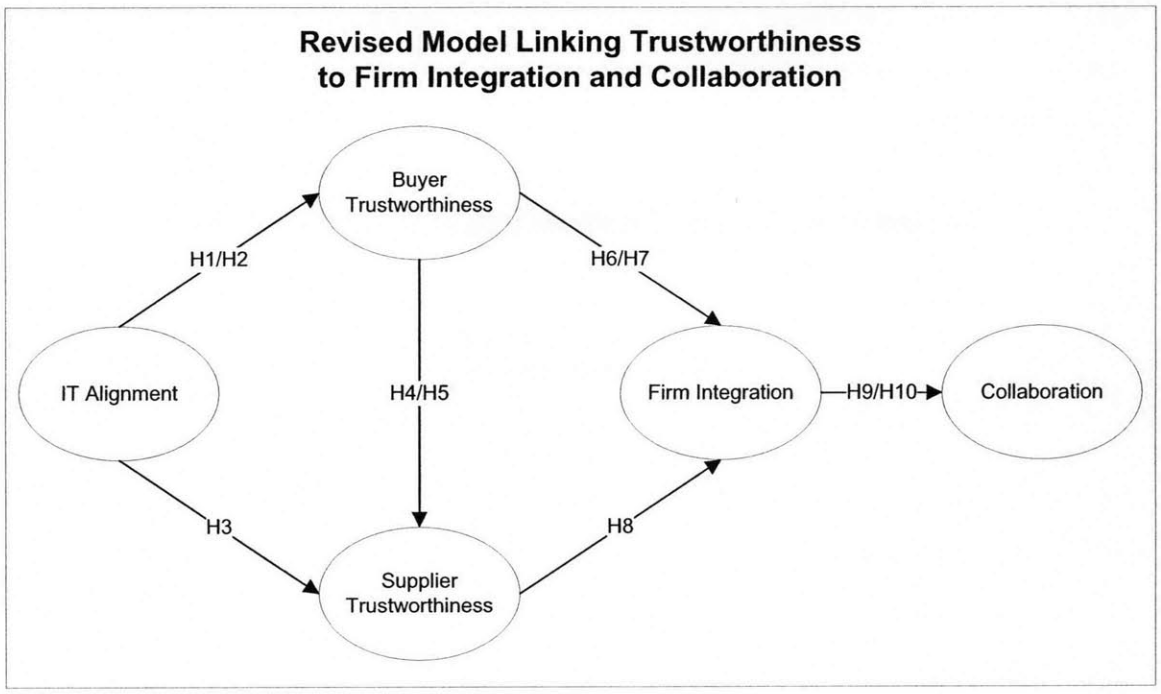

Figure 5: Revised Model (1st Revision)

3.7. Analysis of Model

To maintain simplicity while conducting the structural modeling, the theoretical model was tested as a path analysis model using the mean values for all measures of a factor as the factor's value, as opposed to conducting a full hybrid model.

When the theoretical model was tested using survey data, all paths connected through the factor Integration (IN) were found to be statistically insignificant, with 95% confidence intervals of the path value crossing zero. The theoretical model was revised a second time, removing IN as a factor and connecting the factors for Buyer Trustworthiness (BT) and Supplier Trustworthiness (ST) directly to Collaboration (CO). The corresponding hypotheses were also revised, removing H6/H7, H8, and H9/H10, while adding H11 and H12:

> **H11:** A supplier's perception of their buyer's trustworthiness has a direct and positive impact on their decision to engage in collaborative process innovation and problem-solving with their buyer.

H12: A supplier's perception of their own trustworthiness has a direct and positive impact on their decision to engage in collaborative process innovation and problem-solving with their buyer.

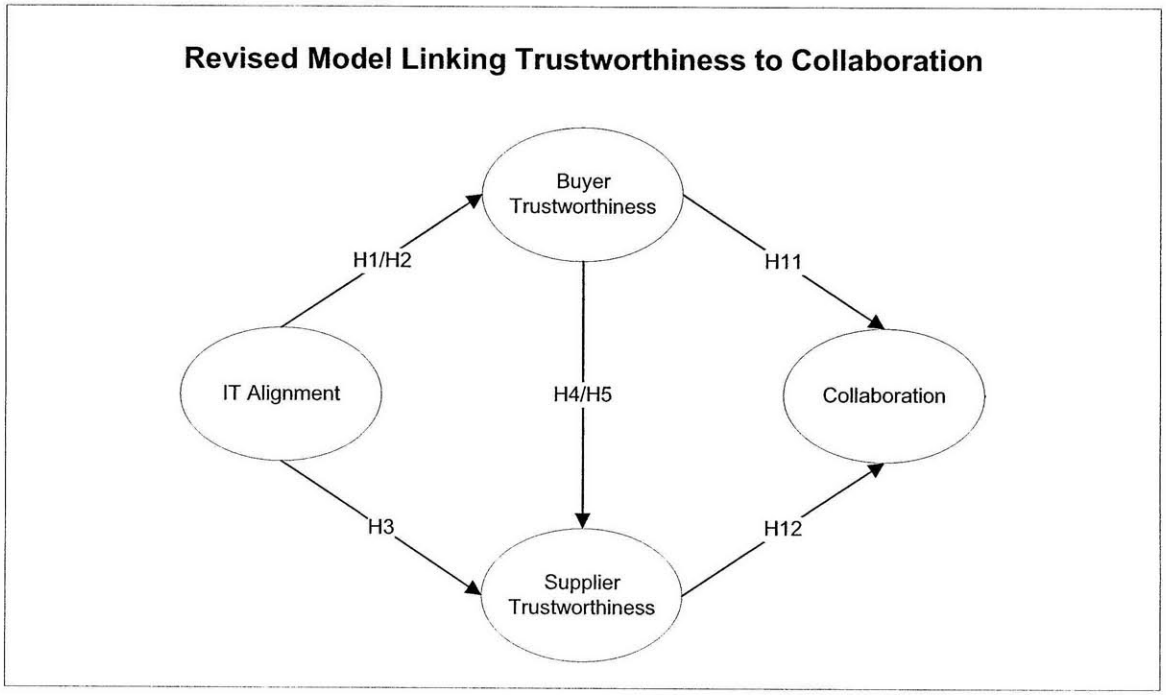

Figure 6: Revised Model (2nd Revision)

3.8. *Assessment of Model Fit*

In attempting to simplify a structural equation model, compromises are often made that reduce the degree to which the model represents the collected data. It becomes important then to determine to what degree a model "fits" the data. Numerous fit indices exist in SEM literature, making evaluation of all of them impractical. Additionally, no one fit index alone can definitively confirm a model's fit is satisfactory. The "minimal set of fit indexes that should be reported and interpreted when reporting the results of SEM analysis" include the model chi-square, root mean square error of approximation (RMSEA), comparative fit index (CFI), and standardized root mean square residual (SRMR). An additional index considered is the Akaike information criterion (AIC) (Kline 2005).

3.8.1. *Model Chi-Square*

The most basic index reported is the model chi-square (χ^2_M) which "tests the null hypothesis that the model is correct... As the value of χ_M^2 increases, the fit of an overidentified model becomes increasingly worse." To reduce the effect of sample size on the model chi-square, a normed chi-square (NC) is derived by dividing by the degrees of freedom (χ^2_M/df_M). "Values of the NC of 2.0, 3.0, or even as high as 5.0... [indicate] reasonable fit" (Kline 2005). Normed chi-square was measured as 0.607, indicating excellent model fit.

3.8.2. *Root Mean Square Error of Approximation*

Another fit index that is favored due to a unique combination of properties is the root mean square error of approximation (RMSEA). The RMSEA is a parsimony-adjusted index, meaning it favors simpler models. Also, RMSEA makes no null hypothesis assumption that the researcher's model is perfect. "The RMSEA is a 'badness-of-fit' index in that a value of zero indicates the best fit and higher values indicate worse fit" (Kline 2005). RMSEA for the model was measured at zero, also indicating excellent model fit.

3.8.3. *Comparative Fit Index*

Another widely used index in SEM is the comparative fit index (CFI), which assesses "the relative improvement in fit of the researcher's model compared with a baseline [null] model... A rule of thumb for CFI... is that values greater than roughly .90 may indicate reasonably good fit" (Kline 2005). The CFI for the model was measured at 1.0, also seeming to indicate reasonable model fit. This may, however, be misleading, as values of 1.0 do not necessarily mean the model has perfect fit, instead only indicating that $\chi^2_M < df_M$:

$$CFI = 1 - \frac{\hat{\delta}_M}{\hat{\delta}_B} = 1 - \frac{max(\chi^2_M - df_M,\ 0)}{\hat{\delta}_B} = 1 - \frac{max(0.607 - 1,\ 0)}{\hat{\delta}_B} = 1 - \frac{0}{\hat{\delta}_B} = 1.0$$

Because of how the model is specified, CFI alone "may not be very impressive" (Kline 2005). However when taken with the rest of the fit statistics, it confirms reasonable fit of the model.

3.8.4. *Standardized Root Mean Square Residuals*

The final minimum required assessment of model fit is the standardized root mean square residuals (SRMR). The SRMR is derived from the root mean square residuals (RMR), which is based on covariance residuals. Transforming the covariance matrices to correlation matrices standardizes the residuals. "The SRMR is thus a measure of the mean absolute correlation residual,

the overall difference between the observed and predicted correlations. Values of the SRMR less than .10 are generally considered favorable" (Kline 2005). The SRMR for the model was measured at 0.05, also indicating reasonable model fit.

3.8.5. *Akaike Information Criteria*

The Akaike information criteria (AIC) is one of the best known predictive fit indexes. Predictive fit indexes assess the model's fit under hypothetical replication. "The model with the smallest AIC is chosen as the one most likely to replicate [the researcher's original sample]. This is the model with relatively better fit and fewer parameters compared with competing models." The model with the lowest AIC (including below zero) is preferred (Kline 2005). The AIC for the model was measured at -1.393, also indicating excellent model fit.

3.9. *Evaluation of Model Hypotheses*

The final path analysis model confirms all five hypotheses of the revised theoretical model. All paths were found to be statistically significant and have direct positive effects. The magnitude of path coefficients is displayed on the final structural model in Figure 7 below.

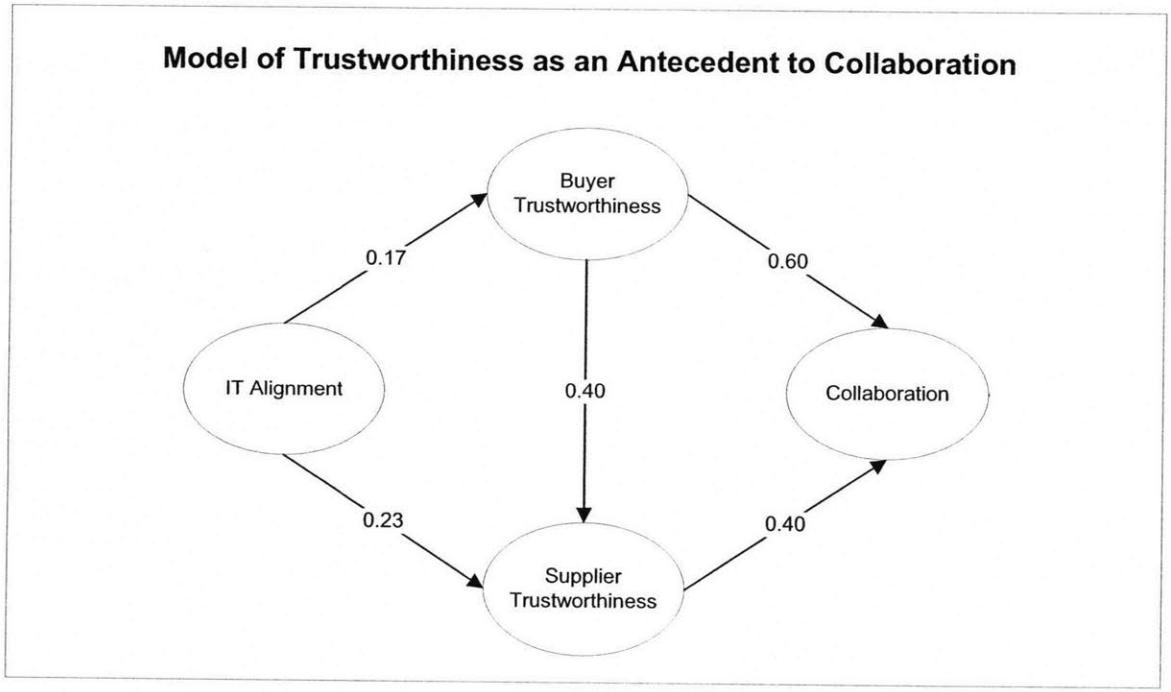

Figure 7: Final Model

This model shows that all three factors – IT Alignment, Buyer Trustworthiness, and Supplier Trustworthiness – can act as antecedents to collaboration. Increasing the relative amount of any of

those factors will lead to an increase in the supplier's tendency to engage in collaborative process innovation and problem-solving with a firm. The path coefficients indicate the relative magnitude of each factor's influence. For example, if a firm can increase their supplier's perception of their trustworthiness by one "unit," it will lead to a corresponding 0.6 "unit" increase in their supplier's desire to collaborate with them.

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4. FRAMEWORK DEVELOPMENT

4.1. *OVERVIEW*

The structural equation model derived in Chapter 3 by itself only provides minimal benefits to business leaders seeking to understand the dynamic of trust in their relationships with suppliers. To take full advantage of the research and analysis, the model must be applied to a conceptual framework that can assist leaders in making decisions and guiding their supplier partnering initiatives. This chapter builds such a framework using Raytheon and their suppliers as an example. Other firms can use this general framework to help develop their own tailored one. This methodology helps companies answer the two main questions: (1) with whom should they share information? and (2) what information should they share?

4.2. *SELECTING THE RIGHT PARTNERS*

Choosing to pursue closer partner relationships with suppliers and actively seeking to build trust through information sharing can be a time and resource intensive process. As such, leaders must first decide the right strategic mix of suppliers to partner with for an initial showcase, and eventually which additional partnerships to pursue. For supply chain managers this boils down to the question which they must ask themselves: "Who should I share information with?"

A potential misconception companies might have is to think that an initiative such as this must be wide-reaching and brought to all of their suppliers. In fact, however, the opposite is true. Trying to reach out to all suppliers would exhaust the resources of most companies. Instead, a "small number of well-designed intercompany operating ties usually can provide a large portion of the potential benefits" (Byrnes and Shapiro 1992). The key is to choose the right companies to approach, both from a perspective of maximizing the effectiveness and probability of success for an initiative, as well as to target companies with the biggest "bang for the buck" improvement potential. An imperative for supply chain leaders developed from previous research highlights the need to "recognize the difference between truly strategic suppliers and other suppliers" (Petersen, Ragatz and Monczka 2005). Thus, selecting which companies to engage is the first step of building a framework.

Raytheon Integrated Defense Systems, for example, utilizes almost 4,000 different suppliers. Their suppliers range from small, family-owned businesses to large industrial conglomerates.

Intercompany coordination for an improvement program with many companies of varying demographics would quickly become staggeringly difficult.

When selecting which suppliers to partner with, companies should begin by identifying all potential suppliers, and then prioritize the list based upon some set of objective metrics. Only then should a company seek to apply subjective decision-making.

Determine metrics. This is crucial to ensure the supplier vetting process will be data driven. Most companies already have some method to evaluate their suppliers' performance. Companies, however, may benefit from reinvestigating their existing metrics to see if they measure what the company is truly concerned with. When deciding upon appropriate metrics, companies should identify both short and long term ones, as well as corporate performance goals. Raytheon, for example, primarily measures their suppliers' performance on quality and delivery statistics on a zero to 100 percent scale. These scores are calculated on a monthly basis. Thus to establish short and long-term horizons, the development of a framework tailored to Raytheon considers their three and 12 month metrics. These time horizons are separated enough to allow any increase or decrease over time to become apparent, but are short enough to remain relevant to current purchasing decisions.

Collect historical data. If companies do not already have a system in place to collect data applicable to the metrics they established, they need to do so next. Most companies will have this information readily available in some form or database. This step also involves collecting data on historical, and if known, future contracts with their suppliers. The simplest method that Raytheon reports contracts is through a rolling 12 month window of purchase order commitments in total per supplier.

Develop a ranking algorithm. This is the most important step in the data-driven side of supplier selection. First, if companies use multiple different metrics, they must create an algorithm that weights the different metrics based upon some form of priority. Some suppliers may be performing at or above targets in some metrics, and therefore the value chain might not benefit as much from pursuing improvements with those suppliers. Accordingly, companies should structure their algorithm to account for suppliers' deviation from targets, both above and below. Finally, companies should incorporate into their algorithm a variable that captures information about the volume of business they do with suppliers.

As an example of this methodology, the author's development of an algorithm tailored to Raytheon is presented. Raytheon uses multiple metrics; in particular quality and delivery ratings.

After interviewing Raytheon employees in their Operational Excellence Center, the author established a weighting for their suppliers' quality at a 60 percent and delivery at a 40 percent. Second, the algorithm for Raytheon accounts for deviations from their target goals of 100 percent quality and delivery. Finally, the algorithm weights each supplier by the total annual contract commitments with Raytheon. Thus, Raytheon's algorithm to determine "contract dollars at risk" (CDAR) is represented by:[2]

$$CDAR = APC * [0.60 * (1 - Q) + 0.40 * (1 - D)]$$

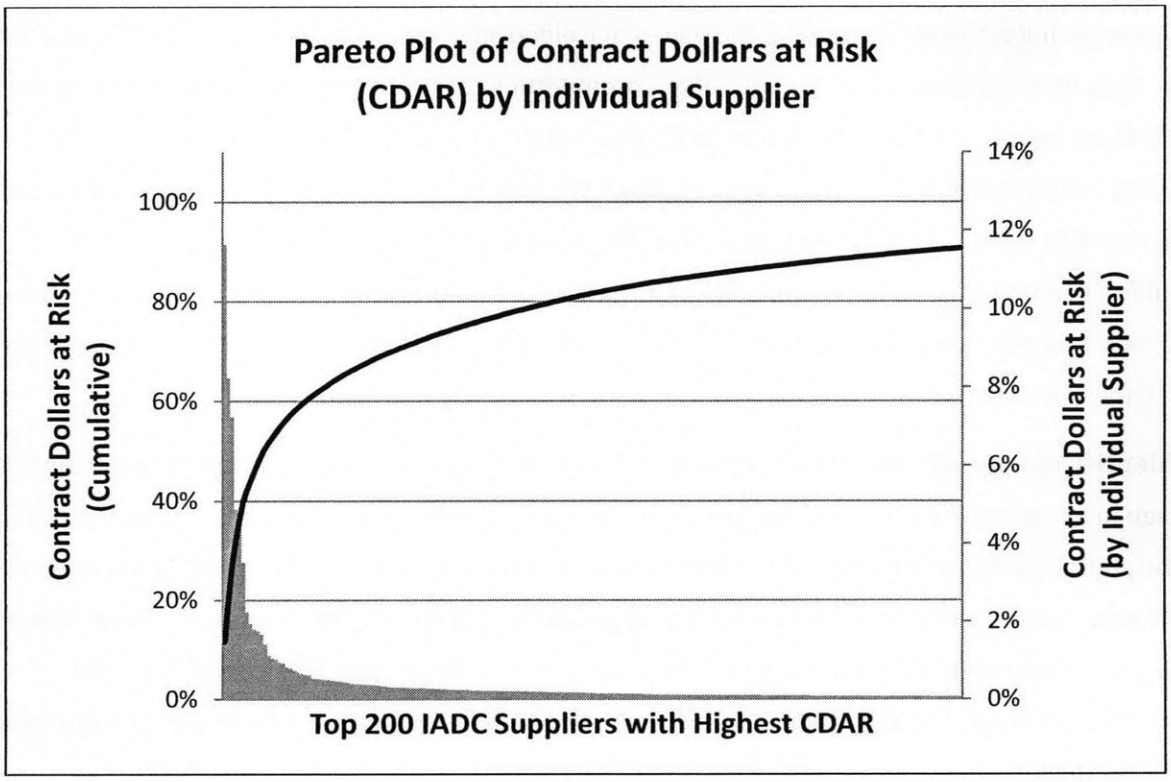

Figure 8: Raytheon Contract Dollars at Risk

The CDAR for each supplier company can be graphed on a Pareto plot to show each supplier's contribution to the overall dollars at risk, as well as to see how large an impact can be derived from improving the performance metrics of a small number of suppliers. In Raytheon's case, evaluation of the data showed that 85% of their CDAR comes from their top 200 "impact" suppliers, while more strikingly, 60% of their CDAR comes from only the top 20. Focusing improvement activities

[2] CDAR = contract dollars at risk; APC = annual purchase commitments; Q = quality; and D = delivery

guided by information sharing with these few suppliers stands to provide a great deal of benefit back to Raytheon.

Identify strategic suppliers. This step is important to incorporate the tacit knowledge in the organization as well as any intangibles that a data-driven process does not account for. For example, purchasing managers may have years of experience with certain suppliers, underlying knowledge of suppliers' culture that may affect improvement efforts, and awareness of other factors that may affect success. This step is also important because it can help companies target suppliers that the algorithm may miss. Raytheon's algorithm, for example, naturally favors suppliers that are either performing very poorly or those that conduct extremely large volumes of business with Raytheon. Beyond all the expensive electronic components that Raytheon purchases, there may be other parts often thought of as commodities that in fact become strategic when they are in short supply. One Raytheon supply chain employee noted to the author: "Even if we're building a high tech missile, something as simple as a washer can bring us to a standstill if we don't have the right ones." Also during this step in the process, determining any strategic "nonselect" suppliers becomes just as important. These suppliers are ones that are determined to either be a poor fit for any improvement activities, or those having some external factor that will jeopardize the chances for success.

Identify change agents. Finally, one of the most vital aspects of selecting the right partners to engage in an information sharing improvement program is selecting "champions" to be the change agents, both inside a company and at their suppliers. Every other step of the process becomes a moot point without somebody driving the change that is able to react to problems. These change agents are preferably those employees with some degree of remaining tenure and have the interpersonal skills that will allow them to cross silo boundaries to align all concerned stakeholders in the campaign.

4.3. Determining the Right Actions

A key component of deciding what information to share with suppliers hinges on understanding what the suppliers want to know. Sharing information with suppliers that they desire will make them more likely to utilize that knowledge to improve the value chain. The external survey tool administered to suppliers also included a section to help the author gauge their preference for different types of information. Gauging a "type" of information that suppliers would like to know is a rather abstract concept, so the author chose to survey respondents' desires for different examples

of potential information to be shared with, representative of the broader classes of information systems (Barki, Rivard and Talbot 1993).

The survey method employed a relatively newer tool used in marketing and product development known as "MaxDiff," short for Maximum Difference Scaling. MaxDiff was pioneered by Jordan Louviere and provides a method for the researcher to determine an absolute comparison of respondents' preferences (Almquist and Lee 2009). Other typical survey methods include rating, ranking, or point allocation. There are several problems with these methods, including difficulty for respondents to indicate their true preference for an item, difficulty in ranking "middle" items, scale bias, and problems with allocating points for summation (Sawtooth Software, Inc. 2007).

MaxDiff provides a useful alternative in which respondents are required to make a series of tradeoffs within small groupings of items. Using multiple rounds of different groupings, it allows the researcher to make an absolute comparison for what items the respondent truly values (Almquist and Lee 2009). MaxDiff is based upon the method of paired choices and conjoint analysis. The logic is that if a respondent rates item A greater than B, and item B greater than C, then A is also greater than C (Sawtooth Software, Inc. 2007).

In the external survey administered to Raytheon suppliers, respondents were asked to conduct most/least important rankings of items representing different types of information a buyer might potentially share with a supplier. The 18 items that were ranked are shown in Table 4 below.

From the external survey of suppliers, 88 respondents answered all questions of information preferences. Respondents without complete data were eliminated from the analysis. The most basic method of analyzing data from a MaxDiff survey is a counting analysis, which provides a quick summary of the average preference of respondents. More intensive methods of analysis are possible, such as Multinomial Logit or Hierarchical Bayes, however for this study a counting analysis was sufficient to fulfill the author's intent (Sawtooth Software, Inc. 2007).

Table 4: Information Systems (IS) Types and Examples

IS Types	Examples of Information Systems
Transaction Processing Systems	Information on parts sold to buyer company(s) that fail receiving quality inspections
	Information on product(s) drop dead dates and quantities
	Point-of-use information on items sold to buyer company(s)
Decision Support Systems	Information on target pricing for quotes
	Information on the buyer's rating of your customer service compared to competitors
	Information on the buyer's evaluation of your risk
Inter-organizational Systems	Access to the buyer company(s) intranet
	Information on future changes to program(s) production levels
	Visibility into the buyer company(s) Bill(s) of Material
Communication Systems	Access to the buyer company(s) employee directory
	Use of an instant chat program shared with buyer company(s) employees
	Your own email account(s) within the buyer company(s) domain
Storage & Retrieval Systems	A shared network drive with the buyer company(s)
	Access to database for quality specifications for parts
	Accessibility to print drawings for parts
Collaborative Work Systems	Ability to schedule buyer company(s) resources (i.e. conference rooms, training assets)
	Advanced information on pending engineering changes to products
	Information on the buyer company(s) current production schedule

For the 18 items presented as options, each item was evaluated based off how many times it chosen as the "most important" selection as a proportion of how many times it was presented overall. All eighteen items were presented a total of 440 times (five times each to 88 respondents). Each item can be represented as a percentage of the times when it had been presented that a respondent chose it as most important (or "least important"). For all 18 items, the sum of percentages for times chosen most important equals k/t, where k is the number of items and t is the number of times each item was presented. The percentages for each item were then normalized to a 100% scale by dividing by k/t (Sawtooth Software, Inc. 2007). The probabilities for each item being selected most and least important are summarized in Table 5 below.

Table 5: MaxDiff Analysis Results for Supplier Information Systems Preferences

Information System	Probability Item Will Be Selected "Most Important"	Probability Item Will Be Selected "Least Important"
Information on parts sold to buyer company(s) that fail receiving quality inspections	18.9%	0.6%
Information on target pricing for quotes	12.1%	2.8%
Information on the buyer's evaluation of your risk	11.7%	2.1%
Accessibility to print drawings for parts	10.0%	1.3%
Information on the buyer's rating of your customer service compared to competitors	8.7%	1.0%
Information on the buyer company(s) current production schedule	6.9%	2.3%
Information on product(s) drop dead dates and quantities	5.3%	4.5%
Access to database for quality specifications for parts	5.2%	2.5%
Information on future changes to program(s) production levels	4.4%	2.1%
Advanced information on pending engineering changes to products	3.7%	4.2%
Access to the buyer company(s) employee directory	2.3%	5.2%
Point-of-use information on items sold to buyer company(s)	2.0%	4.1%
Visibility into the buyer company(s) Bill(s) of Material	2.0%	12.9%
Use of an instant chat program shared with buyer company(s) employees	1.3%	8.6%
Access to the buyer company(s) intranet	1.3%	7.1%
A shared network drive with the buyer company(s)	0.8%	14.3%
Your own email account(s) within the buyer company(s) domain	0.7%	9.6%
Ability to schedule buyer company(s) resources (i.e. conference rooms, training assets)	0.4%	12.5%

Because the aim of the information sharing preference questions was to determine what respondents would like to have shared with them, the overall probability is less important than their relative rankings. To consider both the most and least important probabilities and create an

overall relative scale, each item was assigned two point values based on its positions on the most and least important rankings. The highest "most important" received 18 points while the lowest "most important" received 1. For the "least important" probabilities, point values were reversed so the lowest "least important" received the most points. Points were then summed for each item. Table 6, below, summarizes the overall relative ranking of item preferences from respondents. This helps establish priorities for companies seeking to share information with their suppliers

Table 6: Overall Supplier Information Systems Preference Rankings

Rank	Description
1	Information on parts sold to buyer company(s) that fail receiving quality inspections
2	Accessibility to print drawings for parts
2	Information on the buyer's evaluation of your risk
2	Information on the buyer's rating of your customer service compared to competitors
5	Information on target pricing for quotes
6	Information on the buyer company(s) current production schedule
7	Information on future changes to program(s) production levels
8	Access to database for quality specifications for parts
9	Information on product(s) drop dead dates and quantities
10	Advanced information on pending engineering changes to products
11	Point-of-use information on items sold to buyer company(s)
12	Access to the buyer company(s) employee directory
13	Access to the buyer company(s) intranet
13	Use of an instant chat program shared with buyer company(s) employees
15	Visibility into the buyer company(s) Bill(s) of Material
16	Your own email account(s) within the buyer company(s) domain
17	Ability to schedule buyer company(s) resources (i.e. conference rooms, training assets)
17	A shared network drive with the buyer company(s)

4.4. INFORMATION SHARING "STAIR STEP" FRAMEWORK

Using the MaxDiff analysis of the survey results, the author developed a framework for information sharing in a "stair step" fashion as depicted in Figure 9. The steps are derived by taking the respondents' desires for each type of information as successive steps, moving from most to least desired. As companies have more resources (e.g. time, IT budget, change agents, etc.) to devote to

an information sharing initiative, they can move up the steps. Resource-constrained companies should focus only on the lowest steps of the framework; trying to "be everything to everyone" and fulfill all the steps at once will lead to divided efforts, split attention, and eventually degraded results of any improvement activity.

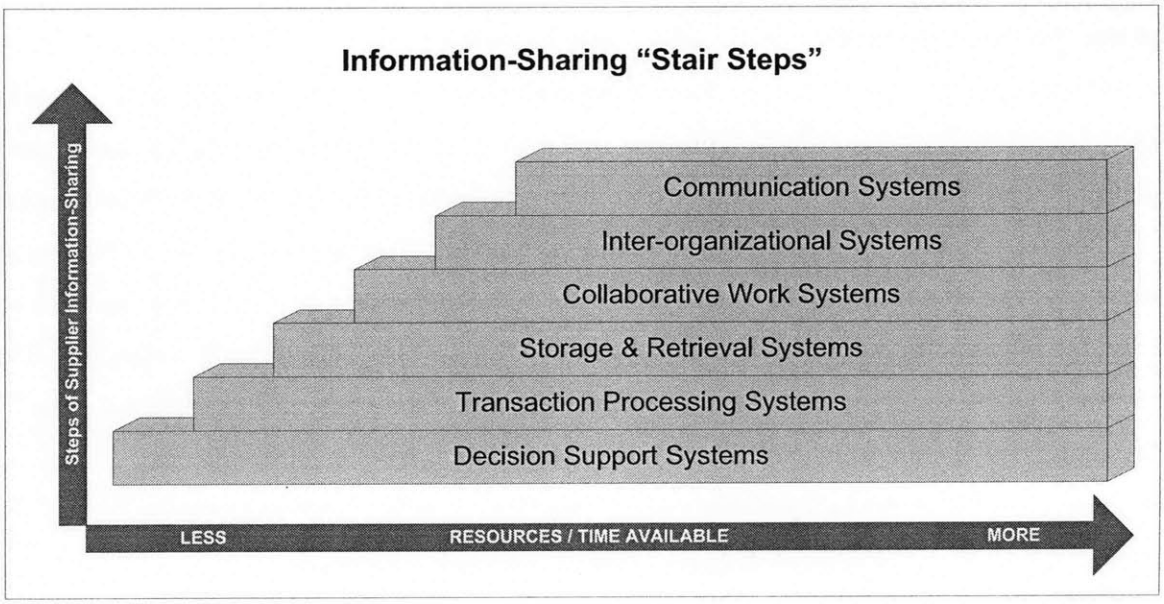

Figure 9: Information Sharing Framework

The information sharing framework reveals that the three most desired types of information systems – decision support, transaction processing, and storage and retrieval – are those that only involve information flows in a single direction. This insight was mirrored in several comments from the external survey of suppliers. Suppliers desire to have access to systems that assist them in making decisions, reduce their time spent seeking information, and provide them more detail when needed. These systems allow suppliers to do their jobs better, faster, and more efficiently. When companies open up their information systems and provide these to suppliers, it will help engender a feeling of trustworthiness in them.

Suppliers' lower desires for the other three types of information systems – collaborative work, inter-organizational, and communication – reveal another key insight. These information systems are those whose benefit increases with network effects: the more people using them, the more beneficial they become. For them to be useful, they rely on information flowing in two directions. These three information systems combined were favored as "most important" by less than 23% of survey respondents. One survey respondent commented: "I find the... supply chain software to be cumbersome and redundant." This suggests that suppliers do not want information systems that

they feel adds additional requirements upon them with little perceived benefit. They loathe new information systems which they feel are cumbersome or redundant, and instead prefer fewer applications that contain more function and are easy and familiar to use.

4.5. *From Model to Framework*

Synthesizing the trust model and stepping stone framework together allows us to move towards an overall conceptual framework of trust-building in the buyer-supplier relationship. This can help firms to understand trust-building as a process, and implement the steps necessary to move their supplier partnerships forward. The author first delineated each of the factors of the final structural equation model – Alignment, Buyer Trustworthiness, Supplier Trustworthiness, and Collaboration – as unique phases in the framework. These factors form the underlying basis of the framework – the attitudes, feelings, and perceptions of those involved in the process, both buyer and supplier. The information sharing stair step model is then overlaid on top of the phases. This represents the specific actions involved within each phase, moving companies from one into the next.

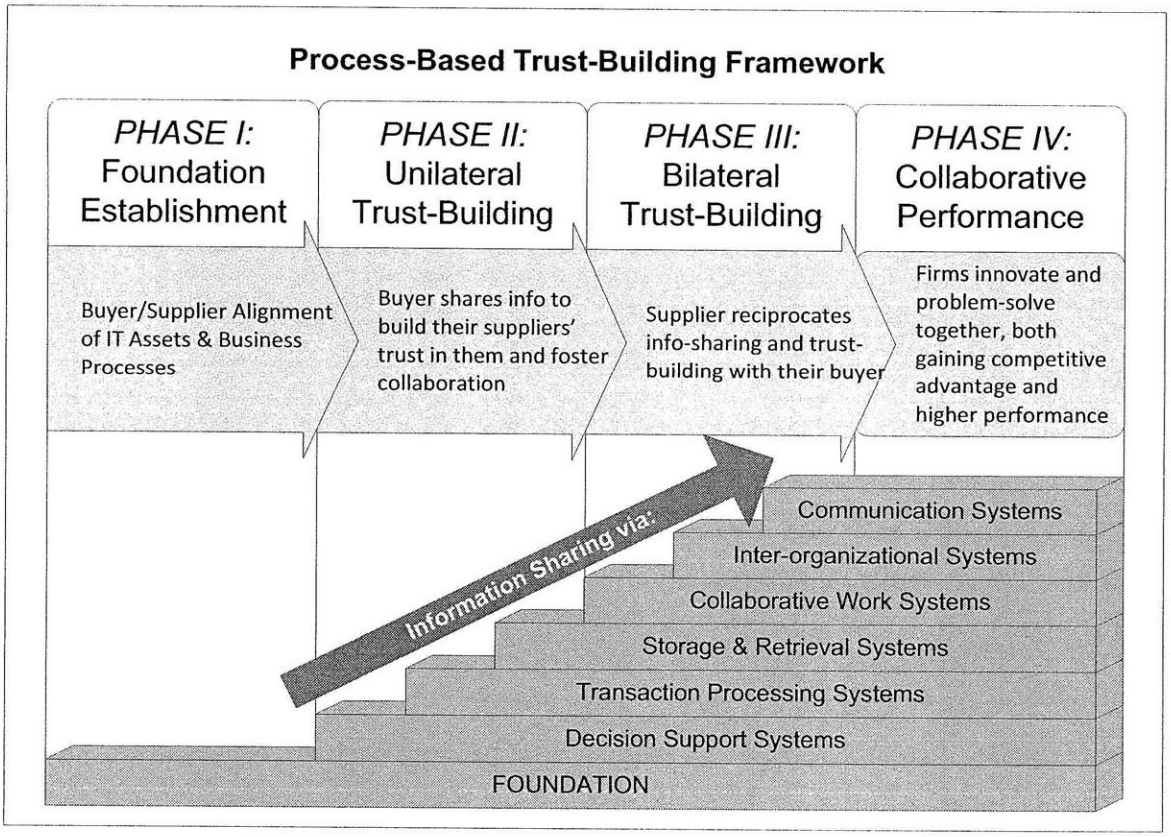

Figure 10: Process-Based Trust Building Framework

To illustrate the phases involved in the process, a hypothetical example follows a qualitative description of each phase:

Phase I: Foundation Establishment. This phase involves the selection of appropriate suppliers to engage in an information sharing campaign aimed at building trust. Supplier selection influences the amount of alignment between a buyer and supplier, both through the selection of suppliers already aligned with a company, as well as through assisting suppliers in aligning their processes and IT systems.

> ACME Rocket-Powered Products, Inc., recently decided to engage in a closer partnering model with some of their key suppliers. As a large government contractor, ACME actively seeks to purchase from smaller, family-owned and disadvantaged businesses. To test their new partnering model, built on the principle of openly sharing information over an IT platform, they decided to conduct a "showcase" with Cogswell Cogs, a family-owned business supply a large volume of widgets. Purchases from Cogswell are one of the largest from any single supplier, as their cogs are used in many of ACME's products. Cogswell has been a consistent supplier for ACME, however there is room for some improvement on their performance metrics. Even though they perform better than many other suppliers, their permeation through multiple programs at ACME has a significant impact, even when metrics drop only by a slight amount. Supply chain managers at ACME believe that Cogswell Cogs will be a good fit for this showcase, as they use many of the same ERP systems as ACME. Their owner, along with ACME's supplier manager responsible for Cogswell, is very eager to improve metrics. Cogswell does, however, have one IT system that is incompatible with ACME's, so ACME helps them negotiate a lower license fee with the software developer, and lends IT support staff assistance to get it up and running.

Phase II: Unilateral Trust-Building. This phase of trust-building can be characterized as companies having to "give" before they can "get." In this phase, efforts to build trust flow in one direction: from buyer to supplier. Actions involve sharing information systems from the first three steps of the information sharing stair step model: decision support systems, transaction processing systems, and storage and retrieval systems. This will stimulate a perception of trust in a company from their suppliers, and encourage suppliers to reciprocate in sharing information.

> Once the new IT platform is in place and the showcase has begun, ACME decides to open up new information on a phased basis to Cogswell Cogs. They first decide to give Cogswell full access to their Intranet and planning and communication tools. They do not, however,

measure any changes in performance. Cogswell employees comment that using those systems only adds burden to their workdays, and see no benefits from their use. Consequently, ACME decides to feed information about their incoming engineering inspections back to Cogswell over the IT platform, as well as make information available about all contract award decisions (keeping the winning bidder anonymous), regardless if those are Cogswell's contracts. The owner of Cogswell values this new information, because now he can identify defective product batches earlier and generate less scrap, as well as plan to bid more competitively on upcoming contracts.

Phase III: Bilateral Trust-Building. This phase entails the reciprocation of information sharing from suppliers. Actions include sharing information systems from the final steps of the model: collaborative work systems, inter-organizational systems, and communication systems. This helps further their desire to collaborate with a company, both through promoting continued information sharing on a firm's part, as well as building their perception of their own trustworthiness and commitment to the partnership.

Now that ACME and Cogswell have both seen some benefits and performance increases since beginning the showcase, ACME requests that Cogswell feed data from their Information Systems into the shared IT platform's database. Having seen the benefits from the previous phase, and trusting in ACME's intentions, Cogswell agrees. Cogswell starts to communicate with ACME over the IT platform, sharing their own internal information that allows ACME planners to make better decisions. Cogswell is also now responsible for updating status information about their own supply on the shared platform, saving ACME supply chain employees time and frustration. They value these benefits, and conversely begin to trust Cogswell and their employees more and are more willing to work as a team to solve problems than taking an adversarial stance.

Phase IV: Collaborative Performance. This phase is the culmination of the process to build trust through sharing information, which is achieved when suppliers have gained enough trust in their customers and feel committed and valued in the partnership. Now companies and their suppliers can truly begin to collaborate and improve the value chain, working far beyond the surface level of partnership.

Having experienced success thus far, together ACME and Cogswell Cogs decide to establish a joint Master Production Schedule, allowing ACME to see the work schedule for Cogswell's cogs, and allowing Cogswell to see the production schedule for finished goods

going to ACME's customers. They can now easily resolve problems in the overall value chain, and more quickly react to problems that affect the schedule. They also set up a collaborative system where engineers from ACME and Cogswell can jointly see and update specifications on parts as they continue to design new revisions. ACME can now get better products to their customers faster, with reduced risk to their supply chain resulting from delays. Cogswell benefits with increased business coming from ACME, as well as sharing the profitability from cutting costs in the value chain that resulted from having better knowledge through information sharing.

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5. CONCLUSIONS AND SUMMARY

5.1. *OVERVIEW*

This chapter summarizes the main findings and conclusions from the synthesis of existing literature and the author's research at Raytheon. The managerial implications of the research and its conclusions are highlighted, broadening the applicability across industries. Some of the potential barriers to employing such an information sharing campaign are addressed with recommended solutions to overcome them. Additionally, the inherent limitations in the current study are highlighted, but lead to potential innovative research in the topic area in the future.

5.2. *MANAGERIAL IMPLICATIONS*

Results of the author's structural equation modeling and qualitative interviews with Raytheon suppliers and supply chain employees clearly suggests that sharing information, in particular over an IT platform, can help establish a company's credibility and build trust with its suppliers. Leaders in companies among various industries who understand the importance of a strong working relationship and high degree of trustworthiness with their suppliers can leverage these findings to start enacting trust-building as a business process.

The antecedents of collaboration can be leveraged in various points. For example, companies can help increase the degree of IT alignment between themselves and their suppliers by helping suppliers to defray the cost of any new software that would be required, or by providing IT expertise and advice. More easily, companies can be selective when choosing IT platforms and attempt to either use open-source software, or choose the lowest cost options to reduce the burden on their suppliers, particularly the smaller locally owned ones. In fact, one Raytheon employee suggested: "We should consider an alternative, free solution if we are to maintain our relationship with smaller suppliers."

Returning to the initial research questions, (1) with which suppliers should companies share information, and (2) what information should they share with those suppliers, we gain some clear insights that companies can take advantage of. Examining Raytheon's metrics for supplier performance clearly indicated that a great deal of gains can be made by engaging a small number of suppliers. This is likely the scenario for most firms, and leaders need to remember to focus their efforts to share information and engender collaboration with those suppliers that will generate the biggest return on investment.

Results of the analysis indicate suppliers most desire information that allows them to do their job easier and better and does not require bidirectional exchange of information. Supply chain leaders should recognize this when designing their own information sharing processes and attempt to provide as much information to suppliers without requiring excessive actions on their part. Over time, as the bonds of trust strengthen, in the spirit of continuous improvement, companies can begin engendering their suppliers to open up their information systems to the company's platform, and begin sharing information in both directions.

5.3. *Challenges to Implementation*

The largest barrier to beginning a process of more effective information sharing with suppliers is in the minds of employees. Many people feel that being an "open book" is a threat to their company and jeopardizes their power in inter-company relations. Stepping back from this initial reaction, it is important to realize that when companies are closed to each other and do not reciprocate strong feelings of trust, they will erect defense mechanisms in other manners that make continuing business more difficult and expensive. Effectively beginning to open up and share information requires a true paradigm shift in mindsets to one of considering oneself and suppliers as "us." This mindset needs to be developed at all levels, but is essential at the upper levels of management, where any doubt or contempt for the process will filter down to the rest of the organization. Also, companies may want to consider such an implementation with newer suppliers instead of established ones. During a reorganization of VF Brands' global supply chain strategy, their leaders learned it was "easier to convince new suppliers than existing suppliers to sign up" because they aren't as set in their ways (Pisano and Adams 2009).

After initiating a process of trust-building, a barrier that will slow its adoption is if the IT platform is slow to be adopted throughout the organizations, particularly at the company itself. Among other reasons, this could happen if the system is too difficult to learn or use, is unreliable and experiences frequent crashes or errors, or if it duplicates functionality from other IT systems and processes. For example, although VBS at Raytheon's IADC is a widely used application among their operations and manufacturing groups, a quick inspection by the author found that it was used by less than one-third of their Integrated Supply Chain employees, and of those that did use it, half of them only did so on average of once per day. These factors need to be taken into account when a company designs its own information sharing process, and it is a continual endeavor for leaders in a company to reevaluate the adoption of their system and redesign it over time.

A final challenge, but a very large one nonetheless, is the security of information passing over such an IT platform, especially when leaving a company's boundaries. Although the author recognizes the advantages of opening up as much information as possible to suppliers, it is important that this information is secured to those suppliers alone. Any information that is not secured can potentially fall into the hands of a company's competitors, or in the case of companies that deal with defense contracting such as Raytheon, into foreign information services' hands. As a defense against data loss, Raytheon employs the use of encoded key fobs with unique personal identification numbers (PINs) for each user. This helps provide a great deal of security, however at the cost of increasing the complexity of utilization of the system for employees and suppliers. For example, if suppliers are required to have their key fobs reauthorized on periodic schedules, it increases the workload on the system just to keep it running, and threatens cutting suppliers off from access to the IT platform, thus negating the benefits of its use.

5.4. Limitations & Future Research

One limitation of this research is that the data collection through the survey tool only collected information from US based companies. Although the author determined that the exclusion of international suppliers would not drastically change the survey data, it is conceivable that companies from other cultures and geographic regions might respond differently. This limitation might limit the applicability of the findings to companies that do more international business than Raytheon. Future research in the area could expand to include perspectives of suppliers from multiple different nations, and could provide very beneficial to the understanding of trustworthiness in supplier partnering in global value chains.

Another potential limitation on the broader applicability of the conclusions of this research are that all the suppliers surveyed served the US defense industry. Again, the author reasoned that this limitation did not significantly change the results, as many of Raytheon's suppliers serve manufacturing customers in many other industries, and their demographics are representative of a broad range of company sizes and compositions. However the business-to-business interactions in companies in particular industries may have unique dynamics, particularly under the strains of different economic forces, so further exploration is definitely warranted.

The survey tool itself is also creates a limitation on the conclusions drawn from the survey data. When determining suppliers' desires for specific types of information to be shared, the author relied on representative samples of information derived with the assistance of a supplier to Raytheon. These were used to gauge the broader desire for types of information systems, but again,

different companies and industries may have information flows that are very unique unto themselves, and evaluating the usefulness of all of them would be prohibitively difficult. Future research could focus individually on each different type of information system and provide more detailed knowledge on what information builds trust between business partners.

One demographic of Raytheon's suppliers not explored in relation to trust-building with suppliers is the history and existing length of relationships between firms. This potentially limits the data drawn from the survey, however the sample selection was broad enough to mitigate this effect. It does, however, lead to another related research question that could be pursued in future studies: at what point in the buyer-supplier relationship should a company begin to share copious information with suppliers?

5.5. *Conclusions*

Strategic management of a firm's supply chain is a key area for companies to differentiate themselves, and will likely become of greater prominence as globalization and competition increase. In order for companies to shift to a *value* chain model from a *supply* chain, greater coordination and partnering with ones suppliers becomes essential for reducing risk, increasing speed to market, and many other crucial success factors. The ease, or difficulty, with which companies will be able to effectively coordinate with their suppliers is greatly affected by the levels of trust between firms. Those companies that can build credibility quickly and effectively may enjoy more success than others that do not.

In seeking to build credibility with ones suppliers, companies can pursue establishing "trust-building" as a business process. The research for this paper supports the idea that one method by which this process can be institutionalized is through delivering open information over an IT platform. Analysis of the responses from over 250 suppliers to Raytheon shows that the perception of a firm's trustworthiness directly impacts a supplier's desire to collaborate more closely with them. In seeking to build this process, companies can follow the author's process-based trust-building framework, which lays out a methodology to select appropriate suppliers, determine which types of information they can benefit from, and move down a path from unilateral to bilateral trust and collaboration.

APPENDIX A: EXTERNAL SURVEY

Introduction

Thank you for your assistance in helping with my research.

Again, the responses you give to the survey will remain completely anonymous. The data will be used to learn how different suppliers react towards different issues. Trends will be presented to Raytheon to better inform them of their supply base's feelings and desires, however no raw data will be presented that will identify any individual respondent.

At the end of the survey there is a section where you can make any comments about your experiences and/or knowledge that may pertain to my research.

Demographics

The following questions are to describe the characteristics of your company. The demographic data is used to learn how suppliers in different groups feel towards specific issues. Demographic data will not be used to discern respondents' identities.

1) Which option most closely matches your title/position?
   a) Chairman
   b) CEO
   c) President
   d) CFO
   e) COO
   f) CTO/CIO
   g) SVP/VP
   h) Director
   i) Other
2) What types of supplies/services do you provide to Raytheon? Please select all that apply.
   a) Raw Materials
   b) Components/Subassemblies
   c) Office Supplies/Equipment
   d) IT Supplies/Equipment
   e) Industrial Machinery/Tools
   f) Engineering/Technical Services

g) IT Services

h) Other Material Goods

i) Other Services

3) What was your company's total sales from the last annual reporting period?

a) >$15M

b) $5M-15M

c) $1.5M-5M

d) $500K-1.5M

e) $150K-500K

f) $50K-150K

g) $15K-50K

h) <$15K

4) Of the sales total indicated in Question 3, what amount represented sales to Raytheon IDS?

a) >$15M

b) $5M-15M

c) $1.5M-5M

d) $500K-1.5M

e) $150K-500K

f) $50K-150K

g) $15K-50K

h) <$15K

5) What state is your company located in? If multiple locations, please answer for the unit/location that most serves your Raytheon IDS customers.

6) How many employees does your company have?

a) 1-10

b) 11-100

c) 101-1000

d) 1001-10000

e) >10000

7) What is the average age of your company's employees?

a) <30

b) 30-39

c) 40-49

d) 50-59

e) ≥60

8) For your Raytheon IDS accounts, do you have employees dedicated to support only those accounts?

a) Yes

b) No

9) Do you have any dedicated employees on site at the Raytheon IDS customer's location?

a) Yes

b) No

10) Which most closely describes the level of Information Technology (IT) support your company has?

a) Dedicated IT department

b) Full-time contracted

c) Part-time/as-needed contracted

d) Internal ad-hoc

e) None

f) Other

Raytheon Relationships

1) Overall, how would you rate the quality of your company's relationship with Raytheon?

a) Very Bad

b) Bad

c) Neutral

d) Good

e) Very Good

2) Overall, how would you rate the quality of your personal relationships with your contacts at Raytheon?

a) Very Bad

b) Bad

c) Neutral

d) Good

e) Very Good

3) Overall, how would you rate the level of trust between your company and Raytheon?

a) Very Low
b) Low
c) Medium
d) High
e) Very High

Information Technology (IT) Alignment & Integration

For the following two questions, please answer based upon your business relationship with Raytheon IDS.

1) Please indicate the extent to which your Information Technology (IT) solutions are aligned with Raytheon's by having similar:

(Items rated on scale of 1 to 7, 1 being "Minimal Alignment & Similarity," 7 being "Significant Alignment & Similarity")

a) Applications for transaction processing (e.g., order tracking, invoicing, billing, etc.)
b) Applications used in operations processes (e.g., production planning, inventory management, etc.)
c) Applications used for communication (e.g., electronic conferencing, e-mail system, electronic forums, etc.)

2) Please indicate the extent to which you are integrated with Raytheon by:

(Items rated on scale of 1 to 7, 1 being "Minimal Integration," 7 being "Significant Integration")

a) Engaging in buyer-supplier partnering to ensure that each entity is providing input into each other's processes.
b) Utilizing cross-functional teams with Raytheon to engage in activities that support strategic objectives.
c) Engaging in collaborative planning with Raytheon to develop and plan strategic objectives.

Buyer-Supplier Transparency & Accountability

For the following three questions, please answer based upon comparing your business relationship with Raytheon IDS to those with your other customers.

(Items rated on scale of 1 to 7, 1 being "Significantly Less than Other Customers," 7 being "Significantly More than Other Customers")

1) Please compare your relationship with Raytheon to those with your other customers in the following three areas:
   a) Raytheon discloses information about their portion of the value chain.
   b) Raytheon openly shares their business strategy with you.
   c) Raytheon's accounting/cost focus is on creating value through the relationship for both parties.
2) Please compare your relationship with Raytheon to those with your other customers in the following three areas:
   a) Raytheon allows your company to make a fair profit.
   b) Raytheon provides your company with accurate planning information (e.g., purchasing forecast data, on-time specification delivery, etc.).
   c) Raytheon provides your company accurate financial information (e.g. pricing targets, invoice payments, etc.).
3) Please compare your relationship with Raytheon to those with your other customers in the following three areas:
   a) Your company provides information to Raytheon pertaining to your ability to meet Service Level agreements (e.g., on-time delivery, stockouts, etc.).
   b) Your company provides information to Raytheon related to achieving cost reductions (e.g., raw material pricing, scrap reduction, process improvements, etc.).
   c) Your company provides information to Raytheon concerning improving quality (e.g., inspection information, part pedigree tracking, etc.).

Collaborative Process Innovation & Problem Solving

For the following two questions, please answer based upon comparing your business relationship with Raytheon IDS to those with your other customers.

(Items rated on scale of 1 to 7, 1 being "Significantly Less than with Other Customers," 7 being "Significantly More than with Other Customers")

1) Please compare your relationship with Raytheon to those with your other customers in the following three areas:
   a) Engaging in continuous improvement projects together (e.g. kaizens, Six Sigma, etc.).

b) Cooperating on major product changes and new product development.
c) Jointly engaging in major business process changes (e.g., new software deployment, change to supplier managed inventory, etc.).

2) Please compare your relationship with Raytheon to those with your other customers in the following three areas:
   a) Jointly developing metrics to be leading indicators of problems in the supply chain.
   b) Openly acknowledging and resolving deviations from expected performance measures for both parties.
   c) Cooperatively responding to supply chain disruptions and marshaling supply chain resources to overcome shortages and/or excesses.

Buyer Information Sharing

On the following several pages, there will be groupings of items representing types of information a primary buyer (e.g. Raytheon IDS) might potentially share with you as their supplier. These do not necessarily indicate any types of information Raytheon is currently considering sharing. Rather, the goal is to learn what kinds of information can benefit a supplier in order to build a conceptual framework for doing so.

For each of the groups, please select which one (1) item would be most important for your company to have and which one (1) item would be least important. Don't worry about indicating middle choices.

Please evaluate each group independently. Don't worry about how you answered for previous groups or return to earlier pages to change your responses to make them consistent. Some items will appear more than once.

(Respondents ranked the "Most Important" and "Least Important" items among 18 lists of five items in different combinations drawn from the following list)

A shared network drive with the buyer company(s)
Ability to schedule buyer company(s) resources (i.e. conference rooms, training assets)
Access to database for quality specifications for parts
Access to the buyer company(s) employee directory

Access to the buyer company(s) intranet
Accessibility to print drawings for parts
Advanced information on pending engineering changes to products
Information on future changes to program(s) production levels
Information on parts sold to buyer company(s) that fail receiving quality inspections
Information on product(s) drop dead dates and quantities
Information on target pricing for quotes
Information on the buyer company(s) current production schedule
Information on the buyer's evaluation of your risk
Information on the buyer's rating of your customer service compared to competitors
Point-of-use information on items sold to buyer company(s)
Use of an instant chat program shared with buyer company(s) employees
Visibility into the buyer company(s) Bill(s) of Material
Your own email account(s) within the buyer company(s) domain

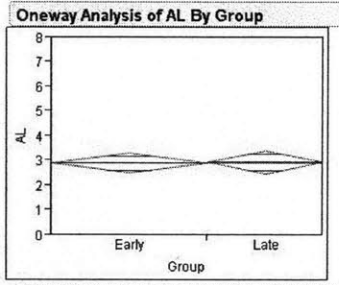
Open Comments and Feedback

1) Please share any insights you have pertaining to trust, accountability, transparency, innovation, and/or problem-solving in a buyer-supplier relationship. I value your input, as it will help me add a "voice" to the rest of the data in the survey. You may comment on your thoughts in general, or specifically pertaining to your business with Raytheon IDS and/or any other customers.
2) Please comment on any other aspects of the survey that will help me to improve it.
3) (OPTIONAL) If you would like to be available for me to contact you with any follow up questions, please provide me with your name and an e-mail address or phone number. Again, all information you provide will be kept strictly confidential.

APPENDIX B: SURVEY DATA ANALYSIS

INDEPENDENT SAMPLE T-TESTS FOR NON-RESPONSE BIAS

Oneway Analysis of AL By Group



Oneway Anova

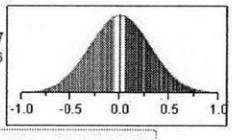
Summary of Fit

Rsquare	0.000264
Adj Rsquare	-0.00917
Root Mean Square Error	1.587102
Mean of Response	2.941358
Observations (or Sum Wgts)	108

t Test

Late-Early
Assuming equal variances

Difference	0.05166	t Ratio	0.167267
Std Err Dif	0.30885	DF	106
Upper CL Dif	0.66398	Prob > |t|	0.8675
Lower CL Dif	-0.56066	Prob > t	0.4337
Confidence	0.95	Prob < t	0.5663



Analysis of Variance

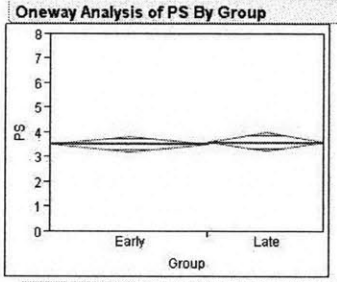
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	0.07047	0.07047	0.0280	0.8675
Error	106	267.00257	2.51889		
C. Total	107	267.07305			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
Early	62	2.91935	0.20156	2.5197	3.3190
Late	46	2.97101	0.23401	2.5071	3.4350

Std Error uses a pooled estimate of error variance

Oneway Analysis of PS By Group



Oneway Anova

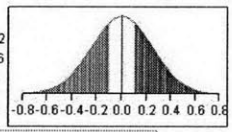
Summary of Fit

Rsquare	0.001905
Adj Rsquare	-0.00751
Root Mean Square Error	1.26854
Mean of Response	3.595679
Observations (or Sum Wgts)	108

t Test

Late-Early
Assuming equal variances

Difference	0.11103	t Ratio	0.449792
Std Err Dif	0.24685	DF	106
Upper CL Dif	0.60045	Prob > |t|	0.6538
Lower CL Dif	-0.37838	Prob > t	0.3269
Confidence	0.95	Prob < t	0.6731



Analysis of Variance

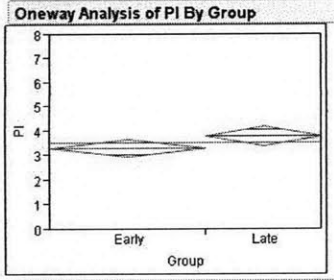
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	0.32556	0.32556	0.2023	0.6538
Error	106	170.57465	1.60919		
C. Total	107	170.90021			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
Early	62	3.54839	0.16110	3.2290	3.8678
Late	46	3.65942	0.18704	3.2886	4.0302

Std Error uses a pooled estimate of error variance

Oneway Analysis of PI By Group



Oneway Anova

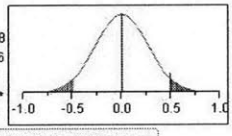
Summary of Fit

Rsquare	0.031369
Adj Rsquare	0.022231
Root Mean Square Error	1.361494
Mean of Response	3.537037
Observations (or Sum Wgts)	108

t Test

Late-Early
Assuming equal variances

Difference	0.4909	t Ratio	1.852788
Std Err Dif	0.2649	DF	106
Upper CL Dif	1.0162	Prob > |t|	0.0667
Lower CL Dif	-0.0344	Prob > t	0.0333*
Confidence	0.95	Prob < t	0.9667



Analysis of Variance

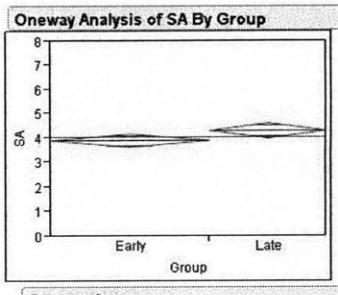
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	6.36331	6.36331	3.4328	0.0667
Error	106	196.48855	1.85367		
C. Total	107	202.85185			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
Early	62	3.32796	0.17291	2.9851	3.6708
Late	46	3.81884	0.20074	3.4209	4.2168

Std Error uses a pooled estimate of error variance

Oneway Analysis of SA By Group



Oneway Anova

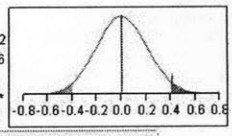
Summary of Fit

Rsquare	0.03509
Adj Rsquare	0.025987
Root Mean Square Error	1.059055
Mean of Response	4.064815
Observations (or Sum Wgts)	108

t Test

Late-Early
Assuming equal variances

Difference	0.40463	t Ratio	1.963362
Std Err Dif	0.20609	DF	106
Upper CL Dif	0.81322	Prob > |t|	0.0522
Lower CL Dif	-0.00396	Prob > t	0.0261*
Confidence	0.95	Prob < t	0.9739



Analysis of Variance

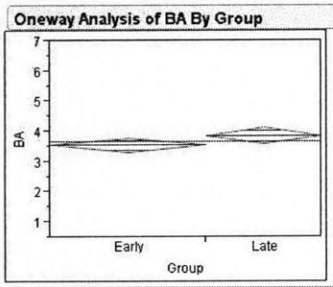
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	4.32353	4.32353	3.8548	0.0522
Error	106	118.88943	1.12160		
C. Total	107	123.21296			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
Early	62	3.89247	0.13450	3.6258	4.1591
Late	46	4.29710	0.15615	3.9875	4.6067

Std Error uses a pooled estimate of error variance

Oneway Analysis of BA By Group



Oneway Anova

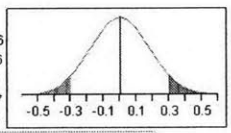
Summary of Fit

Rsquare	0.026494
Adj Rsquare	0.01731
Root Mean Square Error	0.917281
Mean of Response	3.688272
Observations (or Sum Wgts)	108

t Test

Late-Early
Assuming equal variances

Difference	0.30318	t Ratio	1.698476
Std Err Dif	0.17850	DF	106
Upper CL Dif	0.65707	Prob > |t|	0.0924
Lower CL Dif	-0.05072	Prob > t	0.0462*
Confidence	0.95	Prob < t	0.9538



Analysis of Variance

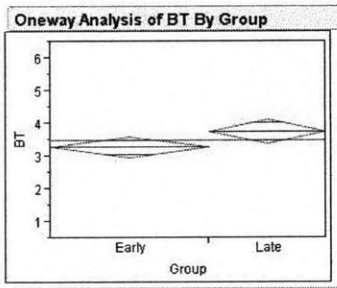
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	2.427304	2.42730	2.8848	0.0924
Error	106	89.188951	0.84141		
C. Total	107	91.616255			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
Early	62	3.55914	0.11649	3.3282	3.7901
Late	46	3.86232	0.13525	3.5942	4.1305

Std Error uses a pooled estimate of error variance

Oneway Analysis of BT By Group



Oneway Anova

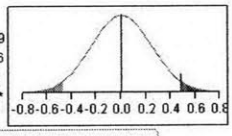
Summary of Fit

Rsquare	0.035579
Adj Rsquare	0.02648
Root Mean Square Error	1.24162
Mean of Response	3.493827
Observations (or Sum Wgts)	108

t Test

Late-Early
Assuming equal variances

Difference	0.47779	t Ratio	1.977489
Std Err Dif	0.24162	DF	106
Upper CL Dif	0.95682	Prob > |t|	0.0506
Lower CL Dif	-0.00123	Prob > t	0.0253*
Confidence	0.95	Prob < t	0.9747



Analysis of Variance

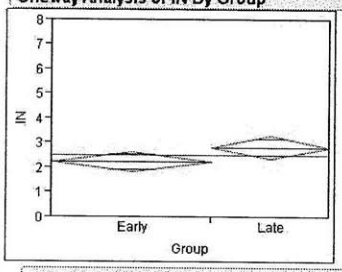
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	6.02845	6.02845	3.9105	0.0506
Error	106	163.41187	1.54162		
C. Total	107	169.44033			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
Early	62	3.29032	0.15769	2.9777	3.6030
Late	46	3.76812	0.18307	3.4052	4.1311

Std Error uses a pooled estimate of error variance

Oneway Analysis of IN By Group



Oneway Anova

Summary of Fit

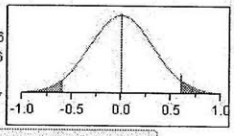
Rsquare	0.03187
Adj Rsquare	0.022736
Root Mean Square Error	1.647508
Mean of Response	2.518519
Observations (or Sum Wgts)	108

t Test

Late-Early

Assuming equal variances

Difference	0.5989	t Ratio	1.867986
Std Err Dif	0.3206	DF	106
Upper CL Dif	1.2345	Prob > |t|	0.0645
Lower CL Dif	-0.0367	Prob > t	0.0323*
Confidence	0.95	Prob < t	0.9677



Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Group	1	9.47114	9.47114	3.4894	0.0645
Error	106	287.71404	2.71428		
C. Total	107	297.18519			

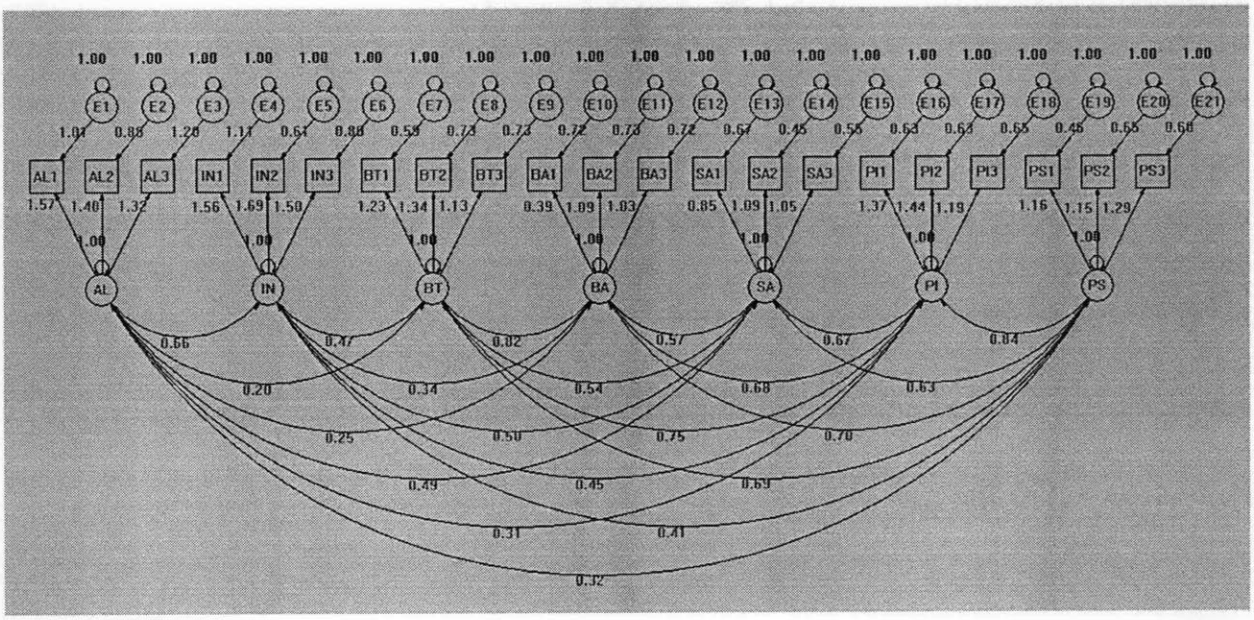
Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
Early	62	2.26344	0.20923	1.8486	2.6783
Late	46	2.86232	0.24291	2.3807	3.3439

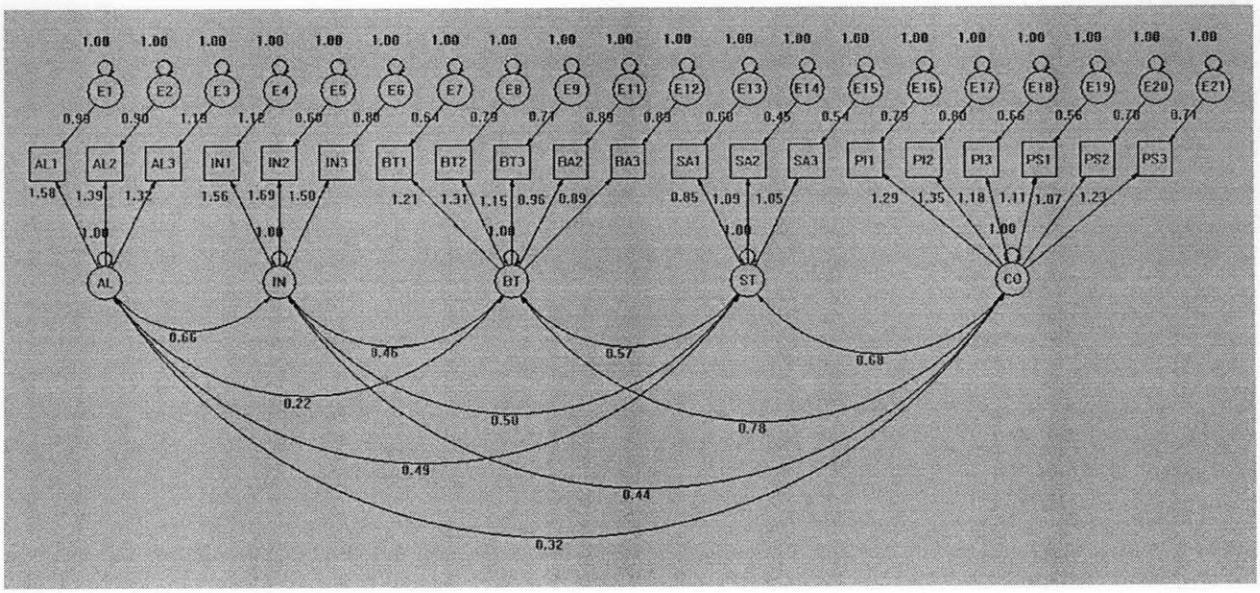
Std Error uses a pooled estimate of error variance

APPENDIX C: MODEL ANALYSIS IN MX

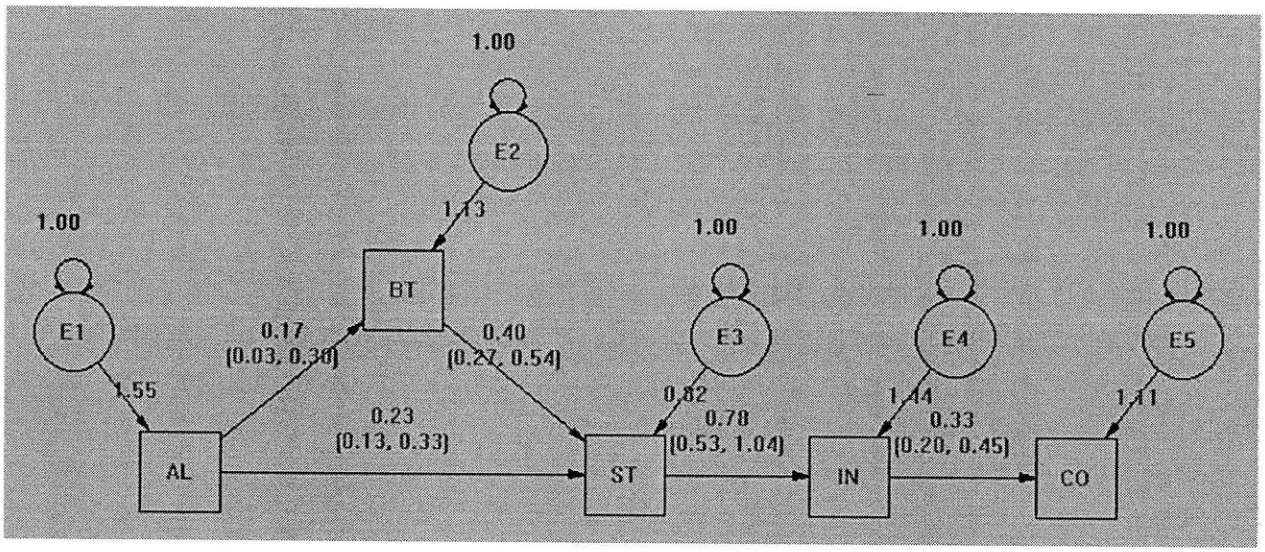
CONFIRMATORY FACTOR ANALYSIS



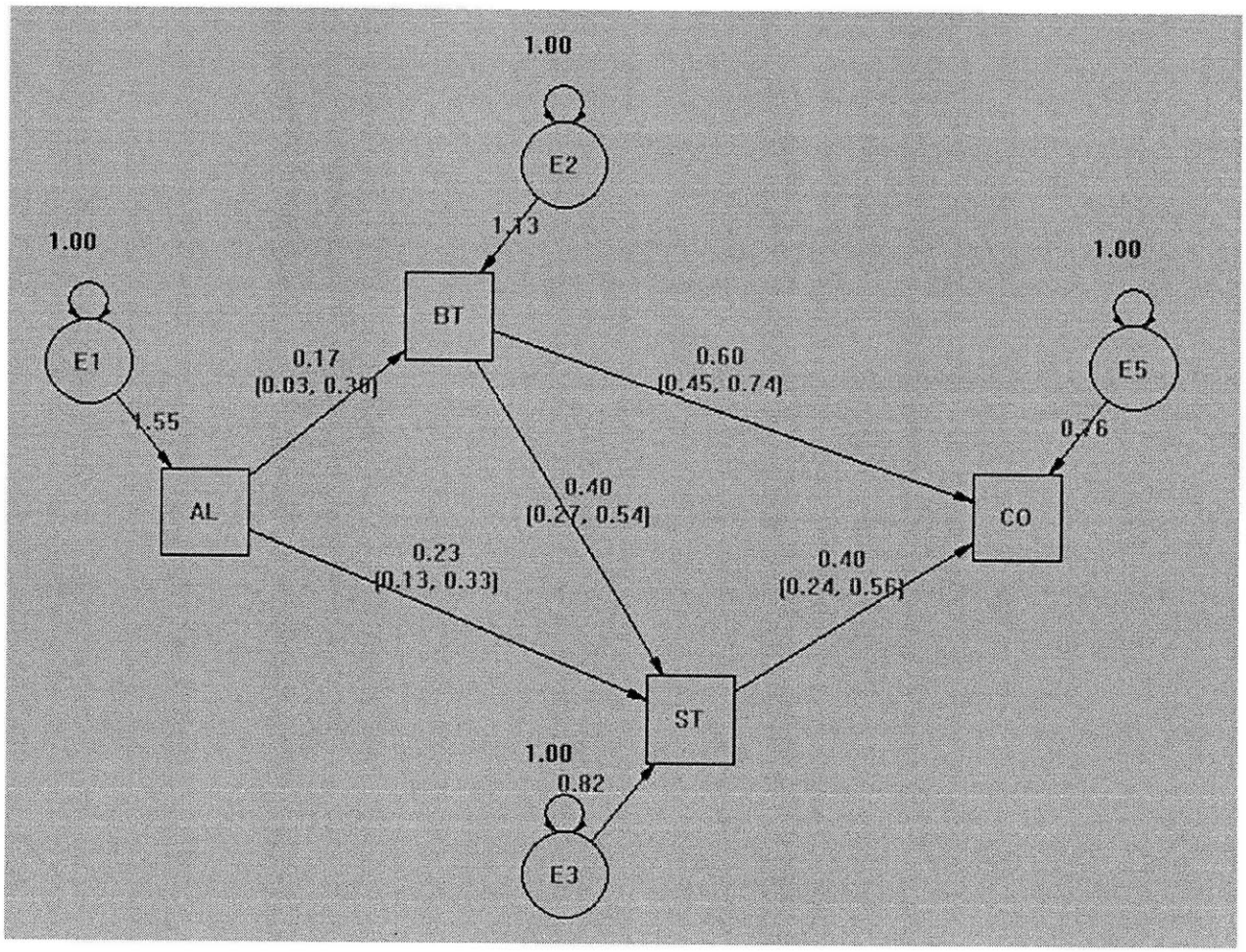
REVISED CONFIRMATORY FACTOR ANALYSIS



PATH ANALYSIS OF INITIAL MODEL



PATH ANALYSIS OF REVISED MODEL



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