

# Integrated Decision Support Model for Global Sourcing

by

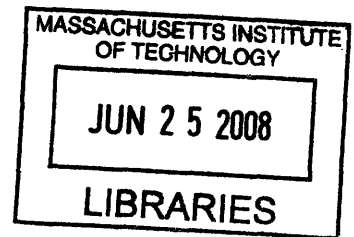
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Submitted to the Department of Mechanical Engineering  
and the MIT Sloan School of Management  
in Partial Fulfillment of the Requirements for the Degrees of

Master of Science in Mechanical Engineering  
and  
Master of Business Administration

In Conjunction with the Leaders for Manufacturing Program  
at the Massachusetts Institute of Technology  
June 2008



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## **ABSTRACT**

Over the last decade, the U.S. aircraft industry has experienced increasing levels of international integration as companies seek to access global talent and resources, cut production costs, spread financial risk, and secure access to airplane markets throughout the world. In an increasingly complex environment, decision makers seek an effective framework to evaluate the true benefits, costs and risks of sourcing alternatives—both relating to the short-term effects of selecting particular suppliers or groups of suppliers, as well as the long-term effects of redrawing their firm boundary and developing a more vertically disintegrated supply chain.

This thesis is an examination of strategic sourcing decision practices at Boeing Commercial Airplanes, based on a six-month internship study with the Future Airplane Production group in Seattle, Washington. In this thesis we will discuss the application of strategic analysis, lean operational analysis, managerial accounting, and Failure Mode and Effects Analysis (FMEA) to improve existing sourcing analysis practices. An integrated decision support model is introduced to represent key sourcing decision factors, their relative importance, and the expected benefits, costs and risks to stakeholders related to each factor (comparing two sourcing alternatives). Using a weighted average, the model expressly indicates the relative value of each alternative.

The model is applied to two case studies involving local insourcing and offshore outsourcing, respectively. This study demonstrates the need for incorporating explicit valuation of ‘softer’ strategic, operational and risk components along with the ‘hard’ financial analysis when making sourcing decisions.

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## ACKNOWLEDGEMENTS

I would first like to thank my wife Danielle for her unwavering support and encouragement during my three years of graduate studies at Jagiellonian University and MIT. Her unique and thoughtful insight has truly enriched my learning, and her editorial skills (including this work) are much appreciated. Most importantly, she has kept our home a place of love, warmth, and comfort, regardless of where we dwell.

I want to thank those leaders in academia and industry who two decades ago created the MIT Leaders for Manufacturing (LFM) program, and those who have supported it ever since. They provide Fellows a once-in-a-lifetime opportunity for deep foundational learning, along with a mandate to go forth and “bridge the divide” between business and engineering through applying our *mens et manus*. It has been an honor to spend the last two years with all my friends and classmates in the Class of 2008. A truly unforgettable experience, I will cherish the memories of our times together.

I would like to thank The Boeing Company and my Future Production System project sponsor Jon Geiger for enabling this project. Jon’s leadership provided a wonderful work environment, and the best support I could have ever asked for. A special thanks to my supervisor Michelle Bernson, for her keen insight and thoughtful coaching. Michelle’s help in connecting me with her network throughout Boeing proved vital for the success of the project. Thank you to my team member Rohit Mathew, who was the rock upon which I often leaned. Rohit earned my unending gratitude for his steadfast support and friendship. Lastly, I thank Lindsey Douglas, who was always ready to lend me a helping hand, and always did her best to keep us all on track.

I am indebted to my thesis advisors, Prof. Stephen Graves and Dr. Stanley Gershwin, for their outstanding support and assistance in completing this work. Never too busy to listen to an idea, always willing to provide brilliant advice, and imbued with passion for teaching—you exemplify the very best of what educators can be. I would also like to thank Prof. Charlie Fine and Dr. Daniel Whitney for their advice and time.

Finally, I appreciate all the great help and valuable lessons offered by the many employees I worked with throughout Boeing Commercial Airplanes, without which this work would not have been possible: Carolyn Corvi; the 737 program: Lane Ballard, Ron Karnes, Dave Hagan, Ken Magness and Katie Baldrige; the 777 program: Kevin Lennox, Howard Gessel and Linsey Rubenstein; the 787 program: Mike VanderWel and Jerry Patzer; the Composite Manufacturing Center: Darren Helle; the Electrical Systems Responsibility Center: Mike Regan; Finance: Dave Leonhardi and Lonny Green; Global Partners: Paul Weaver, Mary Stevens, Cline Tarran, Rick Remedios and Roland Sargeant; Global Strategy: Wade Cornelius, Doug McLaren, and Michelle Mulcahy; Lean Enterprise Office: Carl Mason; Business Strategy and Marketing: Dustin Robinson, Rasheed El-Moslimany; and Replacement Study: Carolyn Brandsema.

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## 1.0 INTRODUCTION

In this era of globalization, one of the major challenges facing companies is to determine how to source for their various products and markets. Global sourcing<sup>1</sup>, combined with outsourcing, has become a principal strategic consideration for many companies as they strive to leverage supply chain activities as a source of competitive advantage. Still, opinions across many industries are that outsourcing decisions rarely fully examine the expected benefits, costs, and risks of outsourcing and are seldom based on a sound trade-off of risks and benefits (Clemens and Hitt, 1997).

### *1.1. Project Description*

As part of a six-month internship study with Boeing's Future Airplane Production group, this work seeks to explore how benefits, costs and risks should be addressed by Boeing Commercial Airplanes<sup>2</sup> (BCA) to inform and motivate global sourcing decisions in the commercial airplane industry. The principal goals of this thesis are four-fold. One, it will examine in detail sourcing practices and trends within BCA, as well as the aerospace industry in general. Two, it will seek to contextualize the current discussion through a literature review of previous approaches toward internal work allocation (i.e. *work transfer*), vertical integration (often referred to as *make vs. buy*), and external supplier selection and management (i.e. *procurement*). Three, it will seek to enhance awareness of the key issues and propose a strategy for approaching important sourcing decisions via an integrated decision support model. Finally, it will illustrate the application of the integrated decision support model using two sourcing case examples.

### *1.2. Approach and Methodology*

In approaching this problem, I focused on acquiring a deeper understanding of the global sourcing challenges facing Boeing Commercial Airplanes to develop insight regarding what factors are relevant and necessary for consideration. At the outset, I conducted informal interviews with Future Airplane Production group members who

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<sup>1</sup> The term *global sourcing* is commonly defined as: strategic sourcing in a global setting aimed “to exploit global efficiencies in the delivery of a product or service.” (Wikipedia, 2008).

<sup>2</sup> This project dealt exclusively with the Commercial Airplanes division of The Boeing Company. Henceforth, unless otherwise noted, all references to “Boeing” refers specifically to Commercial Airplanes.

were interested in helping Boeing make more informed sourcing decisions. After establishing a general understanding of the issues and potential opportunities for improvement, I applied the Six Sigma process design methodology—Define, Measure, Analyze, Design, and Verify (DMADV)—to develop an integrated decision support model for global sourcing.

In order to develop an understanding of the current state, I used three main sources for field research: interviews, strategic sourcing meetings, and historical documentation.

*Interviews.* When conducting face-to-face interviews, I used a semi-structured methodology with a pre-designed questionnaire as a guideline (Appendix A: Interview Questionnaire). Structured topics for discussion included: general perceptions of company sourcing practices, insourcing, outsourcing, and offshoring; how Boeing estimates make/buy opportunity costs; how the company measures and controls internal and external sourcing costs, as well as risk and uncertainty during cost estimation; whether the company has had any disappointments or shocks related to suppliers; what costs have been overestimated or underestimated; and any other requirements or recommendations for a strategic sourcing model.<sup>3</sup>

*Sourcing Meetings.* Monthly meetings of the company's strategic sourcing process committee offered me direct insight into the inner workings of Boeing's process in action. Facilitated by the Global Strategy group, the committee was created for the purpose of aligning the supply chain with overarching company strategy. These meetings provided a valuable perspective on who is actually involved in strategic sourcing, as well as how the company procedures are implemented.

*Historical Documentation.* Company databases and files provided me with documentary evidence of historical sourcing decision processes. My purpose in reviewing historical files was to demonstrate what process record and information the company typically

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<sup>3</sup> Note: Interviews often departed from this guideline in order to explore anecdotal insight related to sourcing practices and principles (both good and bad examples). Such perspectives and lessons were later considered during the design of the model and incorporated, as appropriate.

creates and maintains when considering strategic sourcing, as it relates to organizational learning and process improvement. The review was not an audit of the quality of past sourcing decisions, nor does the absence of key decision factors in documentary evidence imply that these factors were not considered in some way at the time the decisions were made.

Throughout the study, I met with academic authorities in the fields of business strategy, operations research, and finance, as well as Boeing employees at various levels of responsibility and from various business groups to incorporate their feedback and verify the model's validity and usability. Using the model as a framework, I will propose a holistic and standardized approach for global sourcing decision analysis, and offer a set of recommended structural process changes likely to improve the quality of Boeing's global sourcing decision process.

The initial Define phase of the project involved extensive field interviews with employees currently involved with or experienced in the company's sourcing process. These interviews offered insight into how strategic sourcing decisions are generally resolved within BCA, and provided the basis for a current state process map. I defined the "customer" for the model as: a) senior leaders such as the Vice President of Airplane Production ultimately responsible for all strategic sourcing decisions, and b) process stakeholders such as Global Partners, Finance, Fabrication, and other organizations directly responsible for data gathering and analysis support related to strategic sourcing (Appendix B: Stakeholder Map).<sup>4</sup> Through interviews with senior company leadership and process stakeholders, I translated customer needs and expectations into critical-to-quality metrics (Appendix C: Affinity Diagram).

During the Measure phase, I examined company sourcing analysis procedures defined by internally published policies and procedures. Furthermore, I explored historical sourcing documentation from a range of sourcing categories, including: company internal work reallocation, insource-to-outsource work transfers, and military and commercial offset work packages. Based on this documentation, I explicitly

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<sup>4</sup> Stakeholders defined in this work are limited to those directly tied to the strategic sourcing process and outcomes, although indirect benefits from improved sourcing strategy can also extend much further to shareholders, company employees, local communities, and suppliers.

identified the baseline factors BCA typically documented as part of past sourcing decisions.

In the Analyze phase, I examined the company's current gated process for global sourcing decision-making, both in design and in practice, to identify opportunities for process improvement. I attended sourcing strategy and decision analysis meetings, analyzed historical documentation from past sourcing decisions in greater depth, and met with stakeholders to establish key leverage points which might offer the most valuable opportunities for process improvement.

As part of the Design phase, I developed an integrated cost and risk framework for global sourcing, based on input from both literature<sup>5</sup> and practitioners<sup>6</sup>. The conclusion to develop this type of decision support model is based in part on the published practices of leading global firms in other industries. This evidence indicates standardized multi-variable decision analysis can be a useful tool in facilitating effective communication and decision-making.<sup>7</sup> Focusing on the completeness and relevance of the input factors, I chose to apply a straightforward methodology for factor estimation and integration. This involved a simple weighted average method which I used to incorporate the various qualitative and quantitative factor inputs within the proposed framework and derive the model output.

Finally, during the Verify phase, I tested the proposed model's validity and usability using two example case studies—sourcing of vertical fins for the Boeing 737 (offshore outsourcing) and Boeing 777 (local insourcing). As a measure of effectiveness, the model's execution and output should support the overall project objective of helping BCA make more informed global sourcing decisions through: a) helping identify the key factors relevant to strategic sourcing decisions, b) unambiguously communicating and documenting the importance of each factor (through factor weightings and an expected

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<sup>5</sup> The model and proposed methodology incorporate many foundational concepts based on the rich body of academic knowledge, such as: 3-D Concurrent Engineering (Fine), Transaction Cost Economics (Coase and Williamson), Property Rights Theory (Grossman and Hart), and Systems Dynamics (Sterman).

<sup>6</sup> Employees from across Boeing Commercial Airplanes—in groups such as Global Strategy, Global Partners, Future Production System, Final Assembly, Fabrication, Lean, Finance, Marketing, and others—were instrumental in developing and refining the model's list of relevant input factors.

<sup>7</sup> An example of multi-objective decision analysis for sourcing, as applied by IBM, is outlined by Kirkwood, Slaven and Maltz (2005) in their article "Improving Supply-Chain-Reconfiguration Decisions at IBM."

outcome), and c) identifying the most significant anticipated risks. These three characteristics directly support global sourcing decision-making, and also promote process improvement and organizational learning.

Thanks to continued support from the Future Airplane Production team, a follow-on six-month project will continue this study and analyze in greater depth a few key areas to effectively achieve and maintain the desired improvement: a) how to best gather input data through establishment of linkages to *quantitative* data sources and elicitation of *qualitative* data from cross-functional teams; b) refinement of the factor integration method to more effectively incorporate qualitative and quantitative factors; and c) implementation and integration of the future state process design with ongoing sourcing practices.

### ***1.3. Limitations***

A practical barrier for implementing the framework immediately is shortage of information. While strategic and risk analysis is generally qualitative in nature (relating to data where feasible), operational and financial analysis is expressly quantitative in nature. Unfortunately, the current use of traditional financial accounting, control and measurement systems throughout BCA—which “burdens” the cost of direct labor with an aggregated overhead pool ‘tax’ rate—does not align with value stream based decision-making, as I will discuss later in further detail.

It is also important to note that access to information for this study was strictly limited to what company employees were willing to share to an external ‘consultant.’ Thus, whatever documentation and insight I obtained may be incomplete and provide only a partial picture of what decision makers discussed and considered but perhaps did not document as part of past global sourcing decisions.

Finally, the six-month project timeframe served to constrain this work. As the first phase of a multiple-internship study, I chose to sacrifice some depth of analysis and refinement of model sub-elements in order to achieve the necessary breadth of scope. I felt it was important to do so to establish an overarching framework that effectively addresses the multi-faceted and complicated issue of helping Boeing Commercial Airplanes improve its strategic sourcing process.

#### ***1.4. Project Goals and Measurement***

This work is part of an ongoing research study sponsored by Boeing Commercial Airplanes intended to model, analyze, and improve the quality of the company's global sourcing decisions. The desired end state for this project is to contribute to the body of global sourcing knowledge in the commercial aerospace industry, and to formulate substantive process improvements for Boeing Commercial Airplanes.

The project's success will be measured by the extent to which company leaders and strategic sourcing process stakeholders are satisfied with the proposed model and process redesign and its ability to improve the performance of the system. In this work, the *quality* of a strategic sourcing decision is determined based on:

- *Effectiveness*. Performance of the system (e.g. alignment with overarching strategy, satisfaction of stakeholders, etc.).
- *Efficiency*. Within-process step performance (e.g. minimizing non-value added activities, total lead time, etc.)

Ideally, our goal is to make effective sourcing choices efficiently. However, in practice, excessive emphasis on accuracy can add work to the degree that the new process becomes slow and unresponsive to the company's needs. Similarly, efficiency without effectiveness is likely to result in an organization running fast in the wrong direction.<sup>8</sup> If forced to make a choice between efficiency and effectiveness, therefore, we must choose effectiveness.

Of particular note, as components of effectiveness which may be currently lacking, *long-term* focus and *scalability* were most commonly cited as important to incorporate into the design of the model. Senior leaders emphasized the need for future strategic sourcing decision analysis to accurately relate both near-term tactical

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<sup>8</sup> As Yogi Berra once famously remarked when he got lost driving to the Hall of Fame in Cooperstown, New York, "We're lost, but we're making good time!" (Berra, 1998).

considerations and long-term strategic opportunities and costs in support of overarching enterprise goals.<sup>9</sup>

Strategic sourcing process stakeholders identified scalability as a specific objective important to them, in the sense that data gathering and analysis resources should be applied corresponding to the magnitude of the potential opportunities, costs and risks. While very important sourcing decisions may demand significant time and data resources devoted to help ensure effectiveness, for more routine decisions a single supply chain analyst armed with the minimum necessary data should be capable of making effective strategic sourcing decisions.

Having outlined the motivation for the project, specific goals, research methodology, and limitations, Chapter 2 will provide some background information on the company, general trends related to global sourcing, and market projections for the commercial aerospace industry as a whole.

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<sup>9</sup> The terms *strategic*, *operational* and *tactical* used throughout this work relate to the 'levels of command' concept within the military. The word *strategy* derives from the Greek words *stratos* (army) and *ago* (leading), and is the long-term enterprise-level (e.g. Commercial Airplanes) plan of action designed to achieve a particular goal. The *operational* level is concerned with linking strategy to tactics, and relates to the medium-term sequencing, coordination, and resourcing of activities within one area of operations (e.g. 737 Program). Finally, the word *tactical* comes from the Greek word *taktikē*, and refers to the actual techniques employed at the lowest organizational levels on a day-to-day basis (e.g. Procurement Agent, Final Assembly mechanic, etc.).

## 2.0 BACKGROUND AND SOURCING CONTEXT

### 2.1. *The Boeing Company*

The parent corporation of BCA, The Boeing Company (NYSE: BA) is the world's largest manufacturer of commercial jetliners and military aircraft combined.

- Revenue: \$66.4 billion USD (2007)<sup>10</sup>
- Headquarters in Chicago, Illinois
- 161,493 employees across the United States and in 70 countries<sup>11</sup>

Founded in 1916 in Puget Sound, Wash., The Boeing Company has grown over nearly a century to become the world's largest, most diversified aerospace company.<sup>12</sup> In addition to commercial airplanes, The Boeing Company designs and manufactures rotorcraft, electronic and defense systems, missiles, satellites, launch vehicles and advanced information and communication systems. Offering products and services to more than 90 different countries, Boeing is the United States' largest exporter. The company is divided into two large divisions—Commercial Airplanes, which is the focus of this thesis, and Integrated Defense Systems.

In the fifty years following World War II, Boeing established a strong legacy of market dominance in the commercial jetliner industry. The company's early success came from applying technologies developed on military projects, such as the B-47, to commercial jets such as the 707 and 720 (Lawrence and Thornton, 2005).

Capitalizing on a strong first-mover advantage following the war, for half a century Boeing satisfied a tremendous share of global market demand. This has resulted in Boeing's present-day installed base of nearly 12,000 airplanes, or roughly 75% of all commercial jetliners in service worldwide.

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<sup>10</sup> As reported in *The Boeing Company 2007 Annual Report*.

<sup>11</sup> As of March 2008 ([http://www.boeing.com/employment/employment\\_table.html](http://www.boeing.com/employment/employment_table.html)).

<sup>12</sup> Former aerospace companies now part of the Boeing enterprise include: North American Aviation/Rockwell International (1996), McDonnell Douglas (1997), Hughes Space & Communications (2000), Jeppesen Sanderson (2000), and Hawker de Havilland (2000).

## 2.2. Boeing Commercial Airplanes

Boeing Commercial Airplanes (BCA) is the civil aircraft division of the corporation, which accounts for approximately 50% of the total company revenue.

- Revenue: \$33.4 billion USD (2007)<sup>13</sup>
- Headquarters in Renton, Washington
- 65,668 employees<sup>14</sup>

The company is organized into three primary business units: 787 program, Commercial Aviation Services (CAS), and Airplane Programs (AP).

- **787 Program.** Based in Everett, Wash., the 787 Dreamliner is Boeing's newest family of airplanes, expected to enter service in late 2009. The 787 is the world's first mostly composite commercial airplane. As such, its design incorporates advanced materials, systems and engines which provide a twenty percent improvement in fuel performance on a per-passenger basis. Launched in April 2004, the program initially targeted entry into service for late 2008 but has since been delayed due to supply chain challenges. Still, the 787 is regarded as the most successful commercial airplane sales campaign ever (Lococo and Ray, 2008).<sup>15</sup> The work of seventy partner companies who supply the systems and components has been critical to development and launch of the 787. As partners, these suppliers have been asked to take on significantly more responsibility than ever before for managing the extended supply chain.
- **Commercial Aviation Services (CAS).** Based in Seattle, Wash., Commercial Aviation Services operates the industry's largest field service organization, offering support products and services to the BCA global customer base. The company maintains eight spare parts distribution centers with inventory for about 500,000 different types of

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<sup>13</sup> As reported in The Boeing Company 2007 Annual Report.

<sup>14</sup> As of March 2008 ([http://www.boeing.com/employment/employment\\_table.html](http://www.boeing.com/employment/employment_table.html)).

<sup>15</sup> As of Feb. 15, 2008, Boeing has 857 orders for the 787 valued at \$144 billion from 56 airlines.

parts, processing about 1.8 million spare-parts shipments annually. It also develops, manages and delivers the vast amount of technical information needed for fleet maintenance and engineering support.

- *Airplane Programs (AP)*. Based in Renton, Wash., Airplane Programs is responsible for Boeing's main commercial products including the 737, 747, 767 and 777 families of airplanes and the Boeing Business Jet. In addition, another new product in development is the 747-8, a larger, more fuel-efficient and technologically advanced version of the 747.<sup>16</sup>

In 2005, Commercial Airplanes brought a number of internal organizations together in support of a fully-integrated production system—from design through production and delivery—under the leadership of Carolyn Corvi, the Vice President/General Manager of Airplane Production.<sup>17</sup> With roughly 30,000 employees, Airplane Programs is responsible for production and final assembly activities in Renton and Everett, Wash.; component fabrication at Boeing facilities in the United States, Canada and Australia; and Global Partners.

Among the most important stakeholder organizations for strategic sourcing within Commercial Airplanes are Boeing Fabrication (which “makes”) and Global Partners (which “buys”) the components and services required to build a Boeing airplane.

- *Boeing Fabrication*. This division is the largest supplier to Commercial Airplanes, and the largest consolidated operation in the world dedicated to manufacturing airplane parts, assemblies and tools. Boeing Fabrication employs approximately 13,000 people with manufacturing operations in Auburn, Frederickson and Everett, Wash.; Portland, Ore.; Salt Lake City, Utah; Oak Ridge, Tenn.; Winnipeg, Canada; as well as Fisherman's Bend (Melbourne) and Bankstown (Sydney), Australia.

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<sup>16</sup> A freighter version of the 747-8 is expected to enter service in 2009, followed by a passenger version in 2010.

<sup>17</sup> Groups brought together under Airplane Production included: Fabrication, Propulsion, Global Partners, the Airplane Programs and Final Assembly.

- *Global Partners.* The Global Partners organization is responsible for managing the company's supply base for procurement of direct materials. As such, the organization operates in the Seattle, Wash. area near Boeing's final assembly locations, as well as throughout the world at hundreds of supplier locations.

Altogether, The Boeing Company buys billions of dollars worth of products and services each year through contracts with 22,000 suppliers and partners globally. The goods and services fall into the following categories:

**Figure 1: Boeing Global Sourcing Categories**

1	<b>Avionics Systems</b>	communication systems, display systems, cockpit instruments
2	<b>Electrical/Hydraulic and Mechanical Systems</b>	electrical systems, fuel systems, hydraulic systems, control valves, controls, motors, switches
3	<b>Major Outside Production / Major Structures</b>	fuselages & body sections, flight control surfaces, engine structures
4	<b>Purchased Outside Production / Mfg</b>	sheet metal, non-metallic, machined parts, tubing and ducting, etc
5	<b>Propulsion</b>	aircraft engines, thrusters
6	<b>Common Aerospace Commodities</b>	forging, castings, wire bundles, mechanical and electrical adapters, fasteners, microcircuits, retainers, and sealants
7	<b>Interiors</b>	lavatories, interior lighting, carpeting, mats, curtains, survival kits, etc
8	<b>Aerospace Support</b>	maintenance, repair, overhaul services, training, GSE, engineering services
9	<b>Non-Production Goods and Services</b>	Site/Facilities: services, supplies, operations, equipment, maintenance, repairs, construction, and tooling; Supply Chain Services: employee, financial & business solutions services
10	<b>Technical Services</b>	engineering and technical services, software development, embedded software, C3, C3, C4ISR, modeling & simulation, sensors, waveform & networking

### 2.3. Global Partners<sup>18</sup>

*“Our goal in Global Partners is to take ‘real costs’ out of the value chain and take the savings to the market in the form of more competitive airplane pricing.”*

*-Steven Schaffer, VP & GM of Global Partners<sup>19</sup>*

Strategic sourcing within Boeing Commercial Airplanes is governed by a cross-functional executive steering committee consisting of members from approximately twenty internal stakeholder organizations.<sup>20</sup> The committee is responsible for *managing the structure* of the decision-making process and *ensuring alignment* of sourcing decisions with overarching business strategies. It is this group’s responsibility to engage appropriate stakeholders and strategy owners, and make sure they are involved in important sourcing decisions.

A second, subordinate, cross-functional committee of mid-level managers governs the actual sourcing process itself. The purpose of this group is to integrate and *balance stakeholder interests* and company strategies, as well as *provide recommendations, decisions and guidance* in order to optimize work placement. In practice, this group identifies work placement opportunities, facilitates communication between stakeholders, develops recommendations and supporting rationale, ensures regulatory and policy compliance, obtains necessary decision approval, and maintains sourcing process documentation.

For many years, Boeing, like many other North American heavy industry manufacturers, maintained a large supplier network of sub-tier aerospace contractors who the company frequently held at arms-length. During this period, Boeing sometimes awarded contracts to the lowest bidder on the sole basis of price. This practice of supplier selection and management resulted in a number of associated problems, to include shirking, poaching and opportunistic renegotiation.

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<sup>18</sup> Note: The Global Partners organization recently changed its name to Supplier Management. However, I use the name Global Partners, as the group was titled from 2005-2007 and throughout this research.

<sup>19</sup> As quoted by Susan Avery in her article *Suppliers are global partners at Boeing* (Avery, 2006).

<sup>20</sup> The steering committee engages with a broad range of stakeholders responsible for managing areas such as: airplane production strategy, make/buy, supplier management strategy, airplane program suppliers, new airplane program suppliers, commercial airplane services suppliers, process improvement, engineering strategies, market access and industrial participation, human resources, and asset utilization.

While I will explore such risks in greater detail later within the risk management section, an example of opportunistic renegotiation might involve the bidding system for contracts. The structure of a system which rewarded the lowest bidder motivated suppliers to 'race to the bottom' and offer a bid at a price even below their own cost. Suppliers recognized that, after having won a contract, they could achieve their required profit margin by later asserting significant additional charges onto the customer for minor changes in the performance of the contract.

This type of adversarial, 'zero-sum' contest seemed to pit Boeing against its suppliers. The pressure worked both ways, as evidenced by a dinner conversation in Seattle between Richard C. Ill, president of Triumph Group, and Carolyn Corvi, head of Boeing production. Corvi wanted to make certain Triumph was investing enough to make all the flooring, duct systems and other parts Boeing needs, and that it would cut prices as production rates rise. Ill replied, "We'll make dollar investments as long as we're sure we've got the business [from Boeing]" (Greising, 2005).

As described by Property Rights Theory, such a relationship frequently results in underinvestment by the supplier on the customer's behalf (Grossman and Hart, 1986). Suppliers are forced to accept risk that in the future Boeing might abruptly decide to select a different supplier who offered a slightly lower bid. As a consequence, suppliers are less willing to finance customer-specific investments.

To avoid such negative effects, Global Partners has more recently worked hard to evolve the company's strategic sourcing practice towards a longer-term vision of *strategic relationships*. However, it takes time for trust to develop. Eventually, through a core supply base of tight-knit key suppliers of end item assemblies, Boeing now seeks to leverage each supplier's competitive advantages to reinforce Boeing's customer value proposition. According to Steven Schaffer, the VP of Global Partners, the essence of Boeing's current sourcing practices are reflected in how the company: a) selects and views its key suppliers as long-term strategic partners; b) measures and rewards supplier performance with a balanced scorecard; c) encourages suppliers to move up the value chain; and d) facilitates supply base self-regulation through supplier councils (Avery, 2006).

*Establishing Long-term Strategic Relationships.* When first defining the sourcing strategy for the 787 program back in 2001, a team of Boeing supply managers developed a new vision of partnering with internal and external suppliers to improve the supply chain.

As part of the strategy, Boeing chose to dramatically trim down the number of suppliers it works with directly, in order to reshape the value chain. Within five years, the company had trimmed its supply base (for all plane programs) from 3,800 down to 1,200 suppliers (Avery, 2006). The intent was to establish long-term relationships with key suppliers and encourage them to work with their own sub-tier suppliers that were previously directly tied to Boeing. Thus, by turning the company's supply base into *partners* rather than merely suppliers providing parts, the thought was that Boeing could eliminate transaction costs, promote efficiency through the value chain, and help key suppliers expand their work base to become more competitive (Avery, 2006).

*Measuring Supplier Performance.* Across both the commercial and defense sides of the business, The Boeing Company has a well-established standard process to track and evaluate supplier performance. Through the Boeing Enterprise Supplier Tool (BEST), the company evaluates the 17,000 top spend (out of 22,000 total) enterprise suppliers through a composite rating system consisting of three categories: Quality, Delivery, and General Performance Assessment.<sup>21</sup>

*Supply Base Self-regulation.* As described by Schaffer, “[Boeing and its suppliers] help each other through the tough times and are always there to meet the next challenge. Through supplier councils, we actually become accountable to each other, with success as a team the ultimate goal.” (Avery, 2006). In addition to supplier councils, another key tool designed to facilitate system-wide supply base communication and cooperation is an electronic information platform known as Exostar.

Exostar is the aerospace and defense industry's online trading exchange, formed in 2000 by Boeing, Lockheed-Martin, Raytheon, and BAE Systems. Through a common and robust information technology platform, Boeing seeks to overcome the challenges

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<sup>21</sup> The General Performance Assessment seeks to evaluate the degree to which a supplier has appropriate processes in place to be a top performer (Management, Schedule, Technical, Cost, and Quality).

associated with added complexity and geographic distance that has been incorporated into the 787 extended supply chain.

*Increasing Supplier Responsibilities.* For those suppliers selected for the new 787 program, Boeing asked them to take on significant additional responsibilities. Whereas in the past Boeing provided its suppliers with detailed ‘build to print’ engineering specifications, the company now recognizes that doing so may fail to capitalize on the full potential capabilities of supplier partners. Therefore, as part of the new 787 program, the company increasingly turns to its suppliers to deliver a higher level of systems and structures integration, as well as manage their own supply base.

To an unprecedented degree, the suppliers for the 787 Dreamliner share in the risks and benefits of building the new airplane. Suppliers pay their own up-front costs related to engineering, facilities, equipment and tooling. Mike Bair, the former VP of 787 Program, described how Boeing increasingly counts on the supply base for required detailed engineering, by noting: “They are really becoming a true extension of our engineering and manufacturing system” (Steinke, 2005).

*Increasing Outsourcing.* Global Partners leadership has communicated a vision of Boeing’s core supplier base as a competitive strength which can offer the company “around the world technical capability and capacity, access to capital, and enabling technology and strategic positioning” (Avery, 2006). As part of Boeing’s business strategy to focus on large-scale systems integration (LSSI), as well as engage the world’s best aerospace technologies and manufacturing skills, the company has gradually increased its percentage of outsourced work and transferred responsibility for detail engineering designs and production to external suppliers.

A stepwise increase in outsource percentage across all of Boeing’s airplane programs occurred in 2003 when the company sold its commercial aircraft facility in Wichita, Kansas, along with plants in Tulsa and McAlester, Oklahoma.<sup>22</sup> As Boeing increasingly focused on the design and final assembly of its jets in the Puget Sound

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<sup>22</sup> These facilities have seen become Spirit AeroSystems, a first-tier supplier for both Boeing and Airbus.



outsourcing, Prichard and MacPherson point to the dramatic evolution of Boeing's sourcing strategy for key aircraft components across four airplane programs:<sup>23</sup>

**Figure 3: Offshoring Trend for Boeing Airframes**

<b>Airframe</b>	<b>727</b>	<b>767</b>	<b>777</b>	<b>787</b>
<b>Wing</b>	<b>US</b>	<b>US</b>	<b>US</b>	<b>Japan</b>
<b>Center Wing Box</b>	<b>US</b>	<b>Japan</b>	<b>Japan</b>	<b>Japan</b>
<b>Front Fuselage</b>	<b>US</b>	<b>Japan</b>	<b>Japan</b>	<b>Japan/US</b>
<b>Aft Fuselage</b>	<b>US</b>	<b>Japan</b>	<b>Japan</b>	<b>Italy</b>
<b>Empennage</b>	<b>US</b>	<b>US</b>	<b>Foreign</b>	<b>Italy/US</b>
<b>Nose</b>	<b>US</b>	<b>US</b>	<b>US</b>	<b>US</b>

Source: Prichard & MacPherson, 2005

The authors pose the question, thus, to what extent does technology transfer to foreign companies (particularly Japanese companies) represent a good idea in terms of long-run economic or industrial effects for the US aerospace industry? How do other alternatives such as local outsourcing or offshore insourcing relate when considering long-term strategic and operational value to the enterprise?

#### ***2.4. Evolution of Global Sourcing Practices***

Over the past two decades, global sourcing strategy has emerged as one of the most hotly debated management trends. The strategy was initially designed during the late 1980s and early 1990s when many Western firms were faced with strong international rivalry and declining competitiveness. United States and European firms established international purchasing as a key procurement strategy in order to exploit low cost labor pools and global efficiencies in production. By choosing to buy from a low-cost country, companies believed they could improve their cost structure and thus help reverse their decline (Monczka, Trent and Peterson, 2006). While at first most firms viewed global sourcing simply as a cost-cutting procurement strategy, the concept of global sourcing has since expanded to mean much more.

<sup>23</sup> There has never been any significant foreign content for early models such as the 727. From the 767 onwards, however, foreign supply chain partners have clearly become increasingly important (Prichard & MacPherson, 2005).

Global sourcing now includes both the *management of logistics* (identifying which production units will serve which particular markets and how components will be supplied for production) and the *management of interfaces* (among R&D, manufacturing, and marketing) on a global basis (Kotabe and Murray, 2004). While almost any firm can now source components and services from vendors around the world via the internet, the true challenge has become effective integration of sourcing, operations, design, and internal customers located in different countries (Monczka *et al.*, 2006).

Over the past decade, researchers and business managers have increasingly applied a core competency argument to justify increased levels of outsourcing on a global basis. Most recently, dramatic increases in the cost of oil, decreases in the value of US currency, and other unanticipated costs and risks associated with global sourcing have led many firms to reevaluate their sourcing strategy and seek to operate at the “efficient frontier” for their acceptable level of risk.<sup>24</sup>

Global enterprises now focus on developing flexible inter-firm structures that exploit both internal and external suppliers’ competitive advantages, as well as comparative locational advantages of various countries (Kotabe and Murray, 2004). Some firms enthusiastically outsource both locally and offshore as part of a ‘virtual enterprise’ strategy to gain competitive advantage.

Increased competitive pressure is pushing other companies to view outsourcing as a strategic necessity to preserve parity with competitors on cost and/or quality (Clemons and Hitt, 1997).<sup>25</sup> This is reflected in data which indicates that, even as firms experience unanticipated costs and risks<sup>26</sup>, US-based firms are continuing to increase their level of global sourcing (Monczka *et al.*, 2006).<sup>27</sup>

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<sup>24</sup> From Modern Portfolio Theory, the ‘efficient frontier’ is the combination of assets offering the best possible return for a given amount of risk. Conversely, to achieve higher return firms must be willing to accept higher risk.

<sup>25</sup> “A *strategic necessity* is an activity that must be taken to preserve parity with competitors. They are complex enough to require careful execution, but there are few barriers to the duplication by competitors and only limited market imperfections to prevent the acquisition of necessary resources” (Clemons and Hitt, 1997).

<sup>26</sup> In 2007, factories in China were cited as sources of poisonous pet food sold in stores in the United States, dangerous car tires, and lead paint on the popular Thomas & Friends wooden toys (Story, 2007).

<sup>27</sup> Research indicates that by 2010 the total amount US companies spend on foreign goods will represent 41 to 50 percent of their total spend for all goods and materials, compared to 2005 when it was between 31 and 40 percent (Monczka, Trent and Peterson, 2006).

In developing viable sourcing strategies on a global scale, companies must consider not only manufacturing costs, the costs of various resources, and exchange rate fluctuations, but also availability of infrastructure (including transportation, communications, and energy), industrial and cultural environments, the ease of working with foreign host governments, and so on. Furthermore, the complex nature of sourcing strategy on a global scale spawns many barriers to its successful execution. In particular, logistics, inventory management, distance, nationalism, and lack of working knowledge about foreign business practices, among others, are all major operational problems identified by multinational companies engaging in international sourcing. Some studies have shown that despite, or maybe as a result of such operational problems, *where* to source major components seems much less important than *how* to source them (Kotabe and Murray, 2004).

### ***2.5. Aerospace Market Projections***

In general, global demand for commercial airplanes is expected to steadily grow at 5% annually over the next 20 years, amounting to sales of 28,600 new airplanes worth approximately \$2.8 trillion (Boeing CMO, 2007). It is interesting to note the growing significance of the Asia-Pacific, Middle Eastern, Latin American, and Commonwealth of Independent States (CIS) markets, which together amount to more projected revenue than North America and Europe combined.

**Figure 4: BCA 20-yr Regional Demand Forecast**

<b>Market value and airplane deliveries</b>	<b>\$B</b>	<b>Airplanes</b>
Asia-Pacific	1,020	8,350
North America	730	9,140
Europe	660	6,670
Middle East	190	1,160
Latin America	120	1,730
Commonwealth of Independent States (incl. Russia)	70	1,060
Africa	50	490
<b>2006 total</b>	<b>\$2.8T</b>	<b>28,600</b>

Source: Boeing CMO 2007

Boeing's market demand is dispersed globally, with seventy percent of company revenue historically coming from customers outside the United States. This percentage is expected to grow as the overall world economy continues to mature and developing markets continue to open up.<sup>28</sup> Developing countries and regions will likely become more influential on the world stage as their governments seek to leverage access to their rapidly growing markets. Consequently, the rivalry between existing industry players may grow more intense as new entrants seek to join the market currently dominated by Boeing and Airbus.

The dynamic of increased buyer power, combined with the ongoing industry pressure to vertically disintegrate, will certainly require Boeing to carefully choose its strategic position to promote sustained innovation and value capture. To sustain a competitive advantage, the company will need to support its existing core knowledge base while carefully selecting new opportunities for innovation and new competencies. Effective vertical integration decision-making and global sourcing may be among the *most important* factors in the ultimate success or failure of Boeing in the future market.<sup>29</sup>

In summary, Chapter 2 presented a general description of the company and key internal stakeholder organizations, Boeing's current strategy for strategic sourcing, and the higher-level context of increasing globalization and outsourcing as a response to cost pressures and emerging market opportunities. In Chapter 3, I will propose that the first goal of any strategic sourcing decision should be to reinforce the firm's ability to create, capture and deliver stakeholder value. A focus on value stream engineering, knowledge management, competitive positioning, and operational execution—while recognizing exogenous forces and their influence on otherwise optimal strategies—can enable purposeful synergy with the overall enterprise architecture and competitive environment.

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<sup>28</sup> New Open Skies agreements between the European Union and the United States and Canada came into effect in March 2008, and BCA believes further liberalization is imminent in Asian and North African markets as governments ease regulations currently restricting market access.

<sup>29</sup> Fine and Whitney (1996) argue not only that make-buy decisions ought to be a core competence, but that deciding well what to do and not to do is perhaps the most important core competence of all.

### 3.0 REINFORCING ENTERPRISE ARCHITECTURE

*A central principle of systems dynamics is to examine issues from multiple perspectives; to expand the boundaries of our mental models to consider the long-term consequences and “side effects” of our actions, including the environmental, cultural, and moral implications (Sterman, 2000, p.32).*

Beyond creation of unique value, firms must be able to *capture* value. Focusing on the dynamic nature of industries, Germany and Muralidharan (2001) highlight what they consider the greatest challenge of the New Economy: how to bridge the widening gap between value creation and value capture.<sup>30</sup> In contrast to the more static notion of Porter (1996), they suggest focusing on developing a dynamic, adaptable strategic plan to better navigate—and even shape—the emerging rules of the industry.

In Boeing’s case, innovation associated with the new 787 Dreamliner has clearly galvanized customer interest and propelled revenue growth, but it is crucial to recognize that these are simply measures of value *creation*. If Boeing becomes more vertically disintegrated and more design and production work is transferred to outsource suppliers, the company may find it difficult to continue capturing value. Furthermore, as more design and integration work is offered to suppliers and the industry becomes more horizontally integrated, key value capture opportunities may shift toward subsystems (e.g. propulsion, software, etc.).<sup>31</sup>

#### 3.1. Value Stream Engineering

In order to effectively analyze the true opportunities, costs and risks related to sourcing a specific product or process, it is necessary to first view it within a larger system-wide perspective. In addition, if we are to make informed decisions to change a current sourcing process or design a new process, we must strive to truly understand the

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<sup>30</sup> Germany & Muralidharan offer the example of Shawn Fanning, a 19-year old computer student who created tremendous value for millions of online users by allowing them to download free music via peer-to-peer Napster network. However, he could not find any way to capture any of that value for his company.

<sup>31</sup> General Electric enjoys a 20% profit margin for producing engines (1998-2003 Average Data), compared to Boeing’s 4% for assembling the planes (Piepenbrock, 2005). Other examples of powerful component manufacturers in other industries after vertical disintegration include Microsoft & Intel in the computer industry, and Shimano in the bicycle industry.

current state. An effective tool to communicate the current state is an extended value stream map.

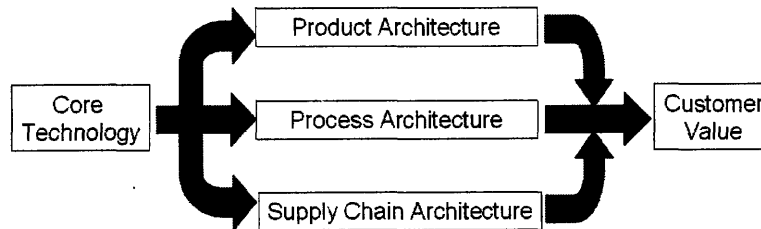
An extended value stream is simply “all of the actions – both value-creating and wasteful – required to bring a product from raw materials into the arms of the customer” (Jones & Womack, 2002, p. 1). There are two basic flows: a) orders traveling upstream from the customer, and b) products coming down the value stream from raw materials to customer, which together constitute a closed circuit of demand and response.

**Figure 5: Example Value Stream**



In knowledge-based industries, the value stream can be visualized more abstractly as core technology being converted—through some combination of product, process, and supply chain interactions—into customer value.

**Figure 6: Consolidated Enterprise Knowledge-Based Value Stream**



At the outset of any strategic sourcing consideration, while seeking to reinforce the firm’s strategic value position, we should begin at the bottom by trying to understand the value and dynamics of the *core technology* involved. Next, we should seek to align product, process, and supply chain dimensions. Finally, we must understand and measure the customer value created or destroyed as a feedback mechanism to enable adjustment of the system and increase of customer value over time.

### **3.2. Knowledge Management and Innovation (Creating Value)**

In economics, New Growth Theory demonstrates that it is *knowledge* which drives sustainable growth (Romer, 1994). Based on this concept, a firm must create new knowledge through innovation in order to achieve increasing economic value. Furthermore, it is the rate of the firm's innovation relative to the industry as a whole which is fundamental to the ultimate success of a knowledge-based enterprise.

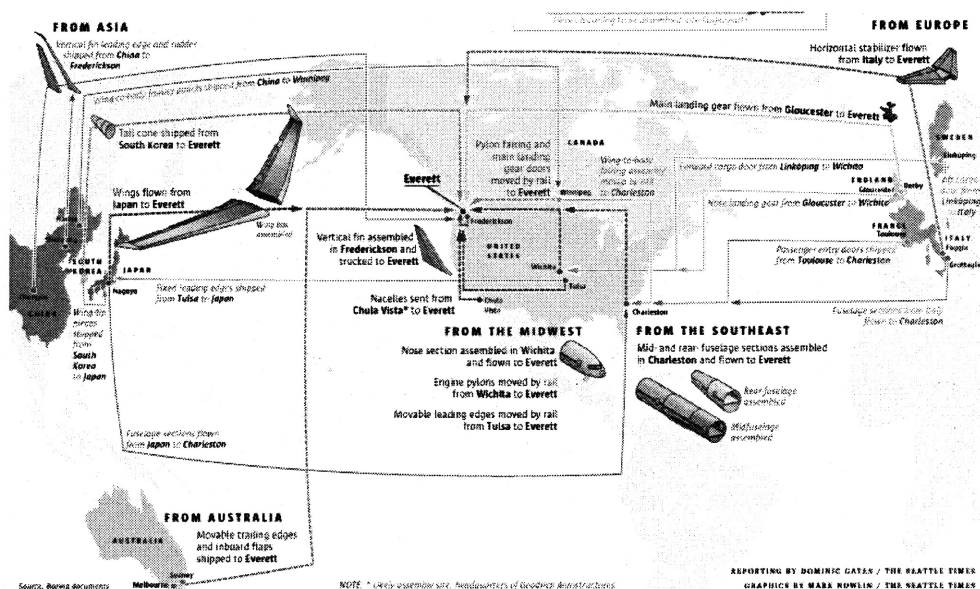
Michael Porter (1998) describes a global environment in which successful industries naturally develop into 'clusters'. Clusters are basically a system of interconnected firms and institutions which together amount to more than the sum of its parts, and develop due to shared common needs for talent, technology, and infrastructure. Porter specifically defines clusters in the following passage:

Clusters are geographic concentrations of interconnected companies and institutions in a particular field. Clusters encompass an array of linked industries and other entities important to competition. They include, for example, suppliers of specialized inputs such as components, machinery, and services, and providers of specialized infrastructure. Clusters also often extend downstream to channels and customers and laterally to manufacturers of complementary products and to companies in industries related by skills, technologies, or common inputs. Finally, many clusters include governmental and other institutions-such as universities, standards-setting agencies, think tanks, vocational training providers, and trade associations that provide specialized training, education, information, research, and technical support (Porter, 1998, p.199).

Clusters affect competition in three broad ways: a) by increasing the productivity of constituent firms or industries; b) by increasing their capacity for innovation and thus the growth of productivity; and c) by stimulating new business formation that supports innovation and expands the cluster. The cluster-based paradigm is popular because it offers a logically compelling, holistic approach to the design and implementation of supply networks.

The key point for firms such as Boeing is to consider the potential value of geographic proximity within a strategic sourcing context. This implies significant value for the enterprise to have its suppliers nearby. The example of the 787 supply chain, which is more geographically dispersed than prior airplane programs (see Figure 7: 787 Globally Dispersed Supply Chain), may prove to introduce large financial and opportunity costs and risks beyond what company planners had initially envisioned. In the future, by designing geographically co-located networks of supplier organizations—whether internal or outsource suppliers—Boeing could best take advantage of the positive cluster-based effects of increased productivity and innovation.

Figure 7: 787 Globally Dispersed Supply Chain



Source: Gates, 2005.

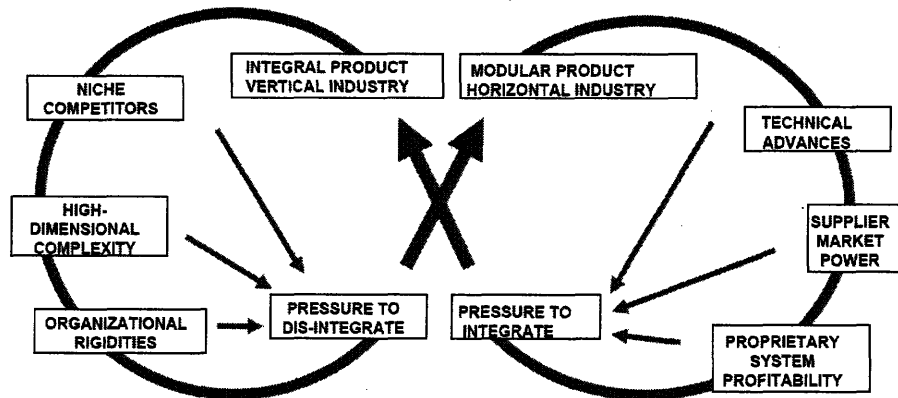
*Industry Dynamics.* The term *clockspeed* is defined as “the velocity of change in the external business environment” (Mendelson & Pillai, 1999, p. 1). Clockspeed is important to consider as part of strategic sourcing because the faster the technology clockspeed for a particular product or service, the more risky it is to be fully dependent on an outside supplier (Fine, 1996). This is because once a supplier or competitor

establishes a lead in a fast clockspeed technology, it may not be possible for the firm to catch back up.<sup>32</sup>

Though difficult to calculate precisely, clockspeed can be generally assessed by examining the rate at which innovators<sup>33</sup> introduce substantially new product technologies (Fine, 1998).<sup>34</sup> In a relative sense, given the long period between new airplane programs, most metrics suggest the commercial aerospace industry is ‘slow clockspeed’. However, within the industry a number of elements, including advanced materials technology, electronics, and alternative fuels, are all evolving at a considerably more rapid pace.

Based on the clockspeed, many industries experience dynamic reconfiguration of the value chain—like a pendulum swinging back and forth—between vertical integration and horizontal relationships. Fine (1998) represents this dynamic as a double helix.

**Figure 8: Fine's Double Helix  
Dynamics of Product Architecture & Value Chain Structure**



Source: Fine, 1998.

<sup>32</sup> Fine (1996) offers the example of IBM, who lost its commanding market position after outsourcing its operating system and microprocessor to Microsoft and Intel, respectively.

<sup>33</sup> An *innovation* is “the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations.” (OECD, 2005, p. 46).

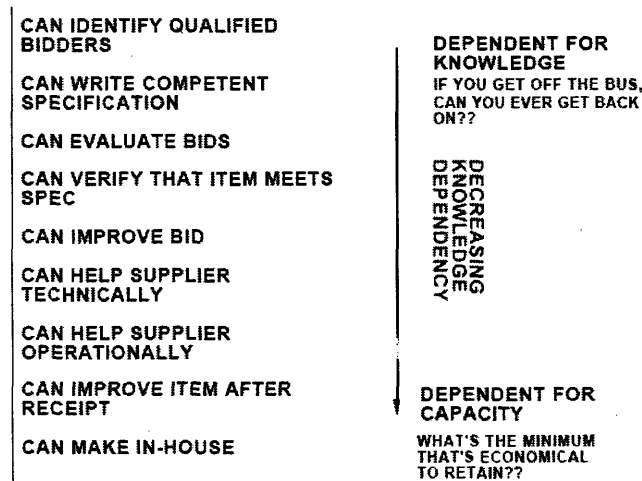
<sup>34</sup> Fine (1998) also suggests other measures such as the rate at which capital equipment becomes obsolete, and the rate at which brand names are established. Other authors have proposed additional measures of clockspeed, such as: average lifecycle of the sector’s products (Blackburn, Guide, Souza & Van Wassenhove, 2004), and the pace of organizational restructuring (Nadkarni & Narayanan, 2004).

Relating this concept to Boeing, after fifty years of being quite vertically integrated, BCA recently appears to be experiencing pressure to vertically disintegrate.<sup>35</sup> Also interesting to note is that Airbus has reported it is planning to sell a number of factories in Europe, and therefore may be experiencing similar pressure.

As firms dynamically reconfigure and consider outsourcing as a component of the business strategy, firms should manage the flow of knowledge that leaves the organization. By outsourcing activities, companies may lose their knowledge concerning the production of core products. Furthermore, outsourcing of such activities may interact with a firm's organizational learning, thereby influencing the future definition of the boundary of what comprises the core activity of the firm.

When firms choose to outsource for knowledge rather than for capacity, they incur a risk of becoming dependent on the supplier (Fine and Whitney, 1996).

**Figure 9: Dependent for Capacity vs. Knowledge**



Source: Fine and Whitney, 1996.

At the top of the list are the minimal skills needed, which comprise the ability to write a competent specification, find or develop a competent supplier, and assure oneself that the specification has been met. These skills are needed regardless of whether the item is ultimately outsourced or not because they represent a recurring task in product development (Fine and Whitney, 1998).

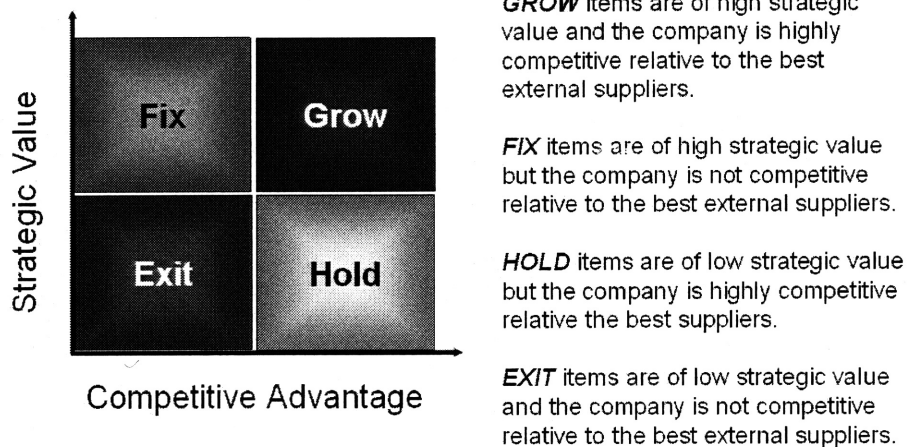
<sup>35</sup> In June 2005, Boeing sold its Wichita, Kansas factory and two facilities in Oklahoma for \$1.5 billion to Onex Corp., which have gone on to become Spirit AeroSystems (Greising, 2005).



The second reinforcing loop, the Hollow Out loop (R2), shows how a decrease in the amount of value-added work done internally results in less value captured, which leads to less net income and, in turn, less resources for research and development. This causes risk-sharing partners to become more attractive, which leads to a greater percentage outsourcing to them, and even less value-added work done internally.

Based on the industry's current structural dynamics—vertically integrated duopoly moving toward a disintegrated multi-competitor industry—it appears that the Hollow Out (R2) loop may increasingly drive the behavior of the system. Boeing, therefore, might consider a strategy to accept a short-term decrease in profitability through decreased high-value outsourcing and increased internal investment. As Prof. Charlie Fine suggests, “when the industry dynamic is moving toward modularity and vertical disintegration, a company can choose to disintegrate under pressure or disintegrate gracefully.”<sup>36</sup> An example framework which Boeing could use to clearly communicate what the company will focus on as part of its future strategy divides products and services into four simple categories: grow, fix, hold and exit.

**Figure 11: Strategic Sourcing Courses of Action**



Source: Fuller, 2001.

<sup>36</sup> This quote is from Prof. Charlie Fine during a 15.769 *Operations Strategy* lecture on March 4, 2008. His point emphasized that by carefully selecting what it does and what it wants to do in the future, a firm may position itself much better to withstand the potentially harmful dynamics of the industry, and even improve its position within the new industry structure.

Having explored the role of knowledge in value creation, as well as the dynamic properties inherent in many industries, how does strategic sourcing for companies like Boeing relate to their ability to capture value?

### 3.3. *Competitive Position (Capturing Value)*

As regulation eases and markets become more global, many firms find sustainable profitability ever more elusive in an increasingly competitive environment. This feeling of hyper-competition has led many companies to imitate everything about their competitors. What, then, is the secret to achieving sustainable competitive advantage? According to Porter (1996), strategy is about creation of unique value through being *different*. A company can only outperform rivals by preserving its unique position, which “arises from both the choice of activities and how they are performed” (Porter, 1996, p. 62). Continued growth is, then, achieved by *deepening* rather than broadening this unique position.

Demarco (2001) points out that the culture in many firms is such that when momentum moves the organization in a given direction, it is taken as strong *a priori* evidence that that must be the right direction.<sup>37</sup> However, momentum in some direction does not necessarily imply carefully planned strategic thinking. While the presumption is that the direction is a result of effective decision-making by leaders, a company can begin to move (or be moved) by a process that is more or less drift. As Demarco describes, Brownian motion<sup>38</sup> within the company asserts a net force in some direction and ‘By God we’re moving’. The key difference between strategic thinking and drift, therefore, is a matter of whether the key choices are made mindfully or mindlessly.

Porter (1996) notes that managers often fail to make strategic choices because trade-offs are frightening, and making no choice often seems preferable than to risk making the wrong choice. In support of the assertion that a company can achieve distinct competitive advantage by learning to make thoughtful and effective tradeoffs, a manager at Apple Inc. attributed the company’s success in strategic positioning as “choosing well

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<sup>37</sup> In some organizations trying to achieve cost reductions, the momentum toward outsourcing may fall into this category.

<sup>38</sup> *Brownian motion* (named in honor of the botanist Robert Brown) is the random movement of particles suspended in a liquid or gas or the mathematical model used to describe such random movements, often called a particle theory (Wikipedia, 2008).

what *not* to do.” For example, compared to other computer companies with a large range of laptop and desktop product offerings, Apple offers only two versions: standard and professional. Dell, on the other hand, offers eight different desktop enclosures.

**Figure 12: Porter’s Alternative Views of Strategy**

<b>Implicit Strategy Model of Past Decade</b>	<b>Sustainable Competitive Advantage</b>
<ul style="list-style-type: none"> <li>• One ideal competitive position in the industry</li> <li>• Benchmarking of all activities and achieving best practice</li> <li>• Aggressive outsourcing and partnering to gain efficiencies</li> <li>• Advantages rest on a few key success factors, critical resources, core competencies</li> <li>• Flexibility and rapid responses to all competitive and market changes</li> </ul>	<ul style="list-style-type: none"> <li>• Unique competitive position for the company</li> <li>• Activities tailored to strategy</li> <li>• Clear trade-offs and choices vis-à-vis competitors</li> <li>• Competitive advantage arises from fit across activities</li> <li>• Sustainability comes from the activity system, not the parts</li> <li>• Operational effectiveness a given</li> </ul>

Source: Porter (1996)

*Transaction Cost Economics.* The earliest theory addressing how to model costs related to the general purchasing or sourcing process is transaction cost economics (Coase, 1937; Williamson, 1975).<sup>39</sup> One reason why the theory is so important is because it represents one of the first and most influential attempts to develop an economic theory that seriously considers the *structure* of firms and the extent to which they integrate vertically.

The traditional economic theory of the time suggested that, because the market is “efficient,”<sup>40</sup> it should always be cheaper to outsource than to hire. Coase noted, however, that besides production costs there are a number of *transaction costs* to using the market, such as search and information costs, bargaining costs, keeping trade secrets, and policing and enforcement costs. Coase argues that the size of a firm is a result of

<sup>39</sup> While transaction cost economics (TCE) is most associated with the work of Oliver Williamson, he has built upon earlier work by Nobel laureate Ronald Coase. In a brief but highly influential essay, *The Nature of the Firm*, Coase explains why the economy is populated by a number of business firms, instead of consisting exclusively of a multitude of independent, self-employed people who contract with one another.

<sup>40</sup> By “efficient” it is meant that those who are best at providing each good or service most cheaply are already doing so.

finding an optimal balance between the competing tendencies of these costs.<sup>41</sup> TCE theory is built upon two assumptions: bounded rationality and opportunistic behavior.

*Bounded rationality* refers to the fact that people have limited memories and limited cognitive processing power. If we can't assimilate all the information at our disposal, we can't accurately work out the consequences of the information we do have, and therefore can't compute the expected utility of every alternative action.

In global sourcing, no matter how knowledgeable they might be, managers cannot consider all the possible alternative courses of action. This is compounded by the fact that in reaching a decision they must take into account how competitors will react. Thus, Gigerenzer and Selton (2002) have shown that simple heuristics frequently lead to better decisions than the theoretically optimal procedure. This is a key assumption because it may be more appropriate for agents to employ 'rule of thumb' heuristics to make decisions, rather than apply rigid algorithmic optimization (Simon, 1957).

*Opportunism* refers to the possibility that people will act in a self-interested way, or as Williamson puts it, "with guile." That is, people may not be entirely honest and truthful about their intentions, or they might attempt to take advantage of unforeseen circumstances that gives them the chance to exploit another party. While not requiring that all people will act opportunistically all of the time, the assumption is merely that some people will act opportunistically some of the time, and that you can't tell in advance who is an opportunist and who is not.

Williamson's contribution has been to specify the variables which determine whether "market or hierarchy" will have the lower transaction costs in various circumstances. The three dimensions Williamson uses to characterize costs associated with any transaction are: frequency, asset specificity, and uncertainty.

1. *Frequency.* Products or services infrequently used by a firm are unlikely candidates for performing internally. For example, whether or not a firm retains attorneys or internal consultants on the payroll relates partly to how frequently their services are needed.

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<sup>41</sup> Coase defines the firm boundary by measuring how many contractual relations are "internal" to the firm and how many "external".

2. *Asset specificity.* When transactions involve assets much more valuable in the context of a specific use, transaction costs will tend to be reduced by vertical integration. We can imagine external suppliers being less willing to invest large amounts in capital assets specific to one customer, compared to what the customer would be willing to invest if it owned the process itself.
3. *Uncertainty.* How difficult is it to foresee the eventualities that might occur during the course of the transaction? The level of uncertainty can relate to duration of the transaction, information asymmetries, and the danger of opportunism.<sup>42</sup>

There are a number of criticisms of TCE theory. First, it assumes that it is possible to neatly separate production and transaction costs, while in practice transaction costs are often hard to define and even tougher to measure. Secondly, while it assumes bounded rationality, it makes little allowance for other key factors which affect decision-making (e.g. power). Finally, transactions may be treated in an oversimplified manner, as though they happen without any knowledge of previous transactions involving the parties concerned. On the contrary, reputation and trust are often important considerations in the transactions of successful firms.

*Opportunity Cost.* A key concept in economics that is very useful when evaluating the cost and benefit of choices is “opportunity cost,” which is the cost incurred (sacrifice) by choosing one option over the next best alternative. Every action has an opportunity cost. The concept implies the choice between desirable, yet mutually-exclusive results. While traditional financial accounting considers revenue and expense cash flows, it fails to consider opportunity cost.

Typically, opportunity cost is expressed in *relative price*, or, the price of one choice relative to the price of another. For example, if a given BCA Machine Fabrication manufacturing cell could either produce 10,000 aerospace-grade fasteners or 50 overhead storage bin arches in a month, then the relative price of a stow bin arch would be 200

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<sup>42</sup> The key question is: Will uncertainty be reduced by vertical integration? And if so, will transaction cost savings outweigh costs associated with vertical integration?

fasteners. In most cases within an efficient economy, the opportunity cost relates closely to the monetary cost, but not always. Thus, the relative price can sometimes provide better insight into the real cost of a good than does the monetary price.

In summary, having considered the importance of a unique position to *capture* value, and understanding the role of transaction cost economics and opportunity costs to help design the boundary of the firm and effectively weigh strategic alternatives, firms should consider how to design the enterprise to best *deliver* customer value.

### ***3.4. Operational Execution (Delivering Value)***

To be effective, strategic sourcing must incorporate higher-level business strategy, and a clear vision of how operational and tactical sourcing decisions support that strategy to create, capture, and deliver customer value. Operational performance and innovation must not be discounted, as it is precisely that which drives financial results. Ironically, however, Hammer (2004) notes that in many modern organizations, financial accounting rather than operations data often dominate the discourse. He relates stories of thousands of managers from hundreds of companies who describe how senior executives almost never understand, support, or encourage operational innovation.<sup>43</sup>

The interactions across the product, process and supply chain dimensions constitute the firm's "operations." As such, these interactions are extremely important in delivering value since they relate closely to the core, value-creating work of enterprises. Examples of the exceptional operations-based value delivery include firms such as Wal-Mart, Dell and Toyota. These companies succeeded in displacing some of the most powerful corporations in the history of capitalism (e.g. Sears, IBM, and General Motors) through their operational excellence and innovation (Hammer, 2004). More recently, other companies such as Zara, a leading-edge Spanish apparel retailer, have implemented process and supply chain innovations to reduce costs and working-capital requirements while simultaneously achieving faster response time than their competition.

Fine (1998) suggests a framework he calls 3-D Concurrent Engineering, which explicitly considers the interfaces among product, process, and supply chain

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<sup>43</sup> One business school student remarked: "There seems to be a hierarchy in the business world. Finance and strategy are at the top, marketing and sales occupy the middle tier, and operations is at the bottom." (Hammer, 2004, p. 88).

architectures, to simultaneously engineer complimentary designs along all three dimensions.

*Product Engineering.* Products can be designed as integral or modular, based on interchangeability of sub-elements, variability of component interfaces, and the extent to which a failure of a component can be localized. A product is modular if it consists of a few well-defined standardized interfaces, such as a component stereo or bicycle. On the contrary, a custom-built motorcycle or jet engine is an integral product with numerous tightly integrated custom interfaces designed for exceptional levels of performance.

Research indicates a strong correlation between product complexity and vertical integration. In a study of the automobile industry, Novak and Eppinger (2001) found that *internal* production is more attractive when product complexity is high. They believe this to be the case because firms often seek to minimize transaction costs and to capture the benefits of their investment in the skills necessary for coordination and development of complex designs.

*Process Engineering.* Processes can be designed as either dedicated, such as batch fermentation to make penicillin, or flexible, such as flexible manufacturing cells. The design of the product and the process should be complementary in the sense that a process should be well-suited to achieve the tolerances specified in the design.

*Supply Chain Engineering.* According to Fine (1998), there are four dimensions which can be seen to relate distance in supply chains—geographic, organizational, cultural, and electronic.

*1. Geographic.* This dimension refers to physical distance and is very important in the design of efficient just-in-time (JIT) supply chains, due to the requirements of frequent deliveries. Geographic proximity can also make coordination and communication much easier during design phases when integrated teams from different firms must work together.

2. *Organizational*. Commonality of goals is referred to as organizational proximity, and is achieved when suppliers and customers have similarly vested interests in the performance of the system. This may be achieved through joint ownership, for example, or through otherwise aligned incentive structures.

3. *Cultural*. This includes elements such as language, laws and business standards, and ethics.

4. *Electronic*. Lastly, the electronic dimension refers to information exchange via internet and electronic data interchange (EDI), which can greatly assist in overcoming distance on the geographic, organizational, and cultural dimensions.

Supply chains can be an integral network such as Toyota City in Nagoya, Japan, or a modular network, such as moviemakers in Hollywood.<sup>44</sup> The enterprise goal should be to match corresponding product, process, and supply chain architectures—to have an integral supply chain in support of an integral product, and likewise a modular supply chain in support of a modular product.

In contrast to an integral supply chain which has close linkages, a modular supply chain may exhibit low proximity along one or more of the four dimensions. They can exist over huge geographic distances, have separate ownership control, have little cultural commonality, and exchange very little data electronically. Either respective supply chain architecture can be effective based on the product context. For example, Dell Inc. has achieved tremendous success through a well-designed modular supply chain of interchangeable arms-length suppliers, flexible assembly processes involving mainly manual labor rather than automation, and a modular product design with well-defined standard interfaces.

In general, as supply chains become extended along any of the four dimensions, costs tend to increase and new risks are introduced. Along the geographic dimension, the increase in cost related to transportation, logistics, and tariffs is relatively straightforward to identify and calculate. However, a lack of organizational and cultural proximity can be

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<sup>44</sup> Note that the most integral supply chain possible is by definition a vertically integrated enterprise.

not only more difficult to appreciate, but also much more difficult to overcome. The Internet and the Web can be helpful in overcoming the effects of geographic distance, but there is still no substitute for face-to-face contact.<sup>45</sup>

*Velocity.* Some experts describe velocity<sup>46</sup> as the most important measure of manufacturing performance, and the single best indicator of lean manufacturing. The reality is that when companies employ global sourcing, supply chains grow longer, more uncertain, and generally less efficient (La Londe, 2006). This results in substantial cost increases for transportation, manpower, warehousing, and IT support. While a low-velocity supply chain does not necessarily translate to lower customer service—if obsolescence risk is low and sufficient inventory is kept on hand—it is necessary to accurately assess the added cost of keeping customers happy in a low-velocity supply chain.

Through mathematical modeling, Prof. Jay Forrester attributed oscillatory behavior in production-distribution systems to be primarily caused by inherent delays in the system (Forrester, 1961). Longer lead times require more inventory and warehousing in the pipeline (increased cost), and if multiple intermodal exchanges take place, the product is more likely to be damaged, delayed, or lost (increased risk). Other questions that extend beyond cost include supply chain adaptability to change or disruptions. As each node in the supply network builds buffer inventories to manage variability, inventories at each channel node become subject to the infamous “bullwhip” effect.<sup>47</sup> As lead times cascade down the supply chain, the ability of supply chains to serve an increasingly demanding customer becomes ever more inadequate.

Boeing has invested a large amount of resources in information technology, which has helped reduce processing delays to a certain extent. However, there are other significant delays inherent to sourcing from external suppliers. For example, in order to increase a supplier’s rate of delivery, it may require additional capacity investment. This

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<sup>45</sup> “Take the look in the customer’s eye when you tell him a new price,” says Thomas W. Malone of the MIT Sloan School of Management. “That’s very useful information” (Garreau, 1999).

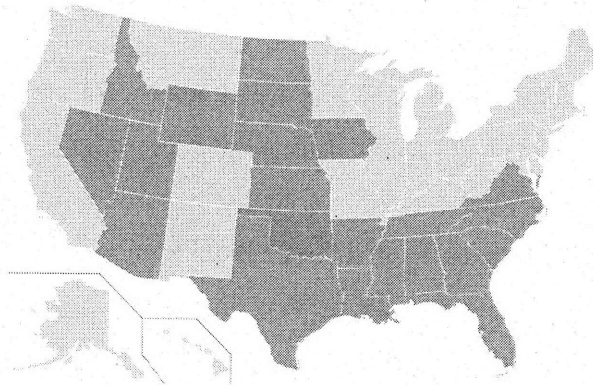
<sup>46</sup> The term ‘velocity’ used in manufacturing refers to ‘time required to get through the factory’ (i.e. speed), not a vector quantity in the physics sense.

<sup>47</sup> The Bullwhip Effect is an observed phenomenon in forecast-driven distribution channels. Oscillating demand is magnified upstream through a supply chain, such that it reminds one of a cracking whip.

may mean airplane production rates would be required to be sustained at a higher level for sufficient time so that the supplier would recoup its investment.

*Union / Labor Relations.* Organized labor unions, as they relate to the supply of skilled labor, may be an important influence on where to source. Over the last decade, increasing globalization has prompted a struggle between US manufacturing firms and labor unions regarding compensation and work flexibility. This has resulted in more firms choosing to place work in geographic locations (both domestically and abroad) that offer reliable, flexible, and reasonable-cost skilled labor pools. In the US, this can lead to work placement in “right to work” states where conflict with trade unions may be less likely.<sup>48</sup> Examples of this trend may include the decision by 787 fuselage contractor Global Aeronautica<sup>49</sup> to locate in South Carolina, as well as the decision by Northrop Grumman-EADS to manufacture US Air Force KC-30 refueling tankers in Alabama.<sup>50</sup>

**Figure 13: US States with Right-to-Work Laws**



<sup>48</sup> *Right-to-work laws* are statutes enforced in twenty-two U.S. States, mostly in the southern or western U.S., allowed under provisions of the Taft-Hartley Act, which prohibit agreements between trade unions and employers making membership or payment of union dues or "fees" a condition of employment, either before or after hiring (Wikipedia, 2008).

<sup>49</sup> Global Aeronautica is a 50/50 joint venture of Alenia North America, Inc. and Vought Aircraft Industries, Inc. which has been contracted to assemble, integrate, test and apply surface finishes to more than 60 percent of the 787 fuselage prior to shipment to Boeing's final assembly facility in Everett, Wash.

<sup>50</sup> As part of a February 2008 contract to Northrop Grumman-EADS, Airbus will begin building all its A330 freighters at a new Mobile, Alabama plant once the deal proceeds (Shalal-Esa, 2008).

Some firms view offshore outsourcing as a hedging strategy against the risk of supplier hold-up from domestic labor unions. One such example appears to be the US auto industry. In recent years, American Axle & Manufacturing (AAM) strategically increased its production capacity offshore in Mexico, China, Brazil, Poland the UK. An ongoing UAW strike which began in Feb. 2008 led to a transfer of some work to AAM's plant in Mexico. The CEO Dauch was quoted as saying: "We have the flexibility to source all of our business to other locations around the world, and we have the right to do so" (Walsh, 2008).

### ***3.5. Exogenous Forces***

In the case of many industries, exogenous factors originating from 'outside the system' play an important role influencing strategic sourcing decisions. Such forces may relate to governmental intervention, a desire to secure market access, or other external motivations. In the case of Boeing, employee interviews indicated a perception that such factors may occasionally outweigh all others in relative importance.

*Commercial and Military Offsets.* The concept of "offset agreements" originated in western Europe during the aftermath of World War II. Post-war Europe was struggling with civil reconstruction costs and found it difficult to cope with the high economic cost inherent in development and modernization of their indigenous military capability. In order to assist, the United States sponsored military and economic grants (such as the Marshall Plan) to help nations achieve the stability necessary to assure they would not collapse. Today, offset in projects requiring high technology such as aerospace and defense is based on the inflow of dollars to compensate for deficits that might arise in the recipient country's national budget, or transfer of work to stimulate technology development in the recipient country.

Increased competition has allowed customers to gradually demand more and more compensation in exchange for US military hardware purchases (US Bureau of Industry and Security, 2007). As categorized by Boeing: *Direct offsets* transfer purchasing dollars and/or work and military technology (often through licensing or joint production) to recipient countries to produce a US weapon system, or its components. *Indirect offsets*

may involve investments in the purchasing country, counter-trade agreements, or transfers of commercial technology (Boeing, 2001).

This dynamic is particularly true in developing countries with less industrialized economies, which pursue indirect offsets to help create profitable commercial businesses and build their infrastructure. One example of a wide-ranging indirect offset obligation involved Boeing's \$1.8 billion sale of F/A-18 fighters to Spain in 1982. This contract included \$1.5 billion in indirect offsets, such as agreements to market Spanish-made steel coils, chemicals, sunflower seed oil, sailboats, paper products, zinc and marble in the United States (Boeing, 2001).

Occasionally, a portion of the Boeing IDS offset obligations is fulfilled by Commercial Airplanes, through placement of manufacturing work in the country or through other non-manufacturing investment. Recently, Ian Q.R. Thomas, President of Boeing India, described that in India, "Boeing has incurred significant offset obligations on the civil side" (Bhargava, 2007). Specifically, Boeing committed to investing \$100 million in a Maintenance Repair and Overhaul (MRO) facility in Nagpur, \$75 million for a new pilot and flight crew training school, and \$10 million to help fund existing pilot training schools in India.

In Chapter 3, we discussed the importance for strategic sourcing to serve as part of a higher-level enterprise strategy to create, capture, and deliver value. In Chapter 4, we will explore some of the tradeoffs of global sourcing alternatives, outline various approaches to quantify costs, and emphasize the importance of effective risk management as an integral part of the process.

## 4.0 GLOBAL SOURCING AS A COMPETITIVE ADVANTAGE

Many contemporary discussions of global sourcing interweave various pros and cons of outsourcing and offshoring into a one-dimensional perspective (e.g. why firms should outsource, or why firms should vertically integrate). Such analysis thereby offers an incomplete picture, useful only in support of one particular sourcing context and strategy. In contrast, based on my research as part of this study, I am convinced that there is no “optimal” global sourcing strategy for every firm—just as there is no best business strategy in general. Rather, the objective of each firm should be to develop a global sourcing strategy that complements its unique business strategy goals and industry context for a specific product or service offering.

Thus, to consider how a firm may use global sourcing as a competitive advantage based on each unique context, we should therefore first attempt to isolate the relative opportunities, costs and risks that relate to alternative scenarios along the vertical integration (insourcing vs. outsourcing) and geographic/political (domestic vs. offshoring) dimensions. Before doing so, it is first necessary to recognize that benefits arising from scale, scope, and specialization can be captured through *either* vertical integration or outsourcing, domestically or abroad, depending on the circumstances.

- *Economies of scale.* When for any reason average costs decline as production increases.<sup>51</sup>
- *Economies of scope.* When the total costs of producing several related goods or services together are lower than the sum of the costs of producing them separately.<sup>52</sup>
- *Economies of specialization.* When the cost of performing only one activity is lower than the cost of performing that activity as one of a portfolio of activities.<sup>53</sup>

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<sup>51</sup> Examples through which economy of scale can be achieved include: dividing fixed development efforts over a larger production scale, accommodating large random variation in demand from any one client over a larger and more stable set of clients, or having dedicated facilities and longer run lengths and thus fewer line changes and reduced down-time resulting from changeovers.

<sup>52</sup> For example, Microsoft enjoys an economy of scope as developer of operating systems and many of the applications packages that run under them.

<sup>53</sup> Benefits of this type come from doing only one process or major assembly item and (as a result of increased focus) doing them better or more efficiently with fewer levels of management coordination than needed in a more diversified organization.

#### 4.1. Vertical Integration vs. Outsourcing

Based on supply management data collected annually throughout the 1990s and global sourcing data collected in the 2000s, the primary factor affecting most firms' decision to source globally continues to be cost-related (i.e. best price/cost, internal margin or profitability requirements, labor cost and availability) (Monczka *et al.*, 2006). The table below outlines some of the other commonly cited benefits of each alternative.<sup>54</sup>

Figure 14: Vertical Integration vs. Outsourcing

Vertical Integration Advantages	Outsourcing Advantages
<ul style="list-style-type: none"> <li>▪ <b>Coordination/Control of Vertical Activities:</b> creates synergies; facilitates communication of detailed design requirements and scheduling</li> <li>▪ <b>Barriers to Entry:</b> enhanced scope of activities, potentially high fixed costs</li> <li>▪ <b>Property Rights:</b> capture all benefits from value chain activities performed</li> <li>▪ <b>Knowledge Specialization:</b> deeper talent pool</li> <li>▪ <b>Knowledge Management:</b> manage and protect intellectual property</li> <li>▪ <b>Control Inputs &amp; Markets:</b> protect quality and access</li> <li>▪ <b>Strategic Depth:</b> investment in specialized assets; differentiation</li> <li>▪ <b>Decreased Cost:</b> avoid supplier search time and contract negotiation; reduce inventory reqt</li> </ul>	<ul style="list-style-type: none"> <li>▪ <b>Decreased Cost:</b> access to economies of scale, more efficient equipment, less overhead, etc.</li> <li>▪ <b>Strategic Agility:</b> decreased capacity and obsolescence risk; transferred to supplier</li> <li>▪ <b>Reduced Time to Market:</b> accelerate product development/production via supplier capability</li> <li>▪ <b>Access Knowledge:</b> supplier intellectual property, experience, knowledge, and operational best practice</li> <li>▪ <b>Access Talent:</b> larger talent pool</li> <li>▪ <b>Decrease Operating Leverage:</b> ratio of fixed costs to variable costs; more predictable variable costs</li> <li>▪ <b>Operational/Financial Risk Management:</b> via supplier partner</li> <li>▪ <b>Improve Quality:</b> via supplier capability</li> <li>▪ <b>Contract:</b> legal redress for non-performance</li> <li>▪ <b>Commodification:</b> standardization of products and processes</li> </ul>

Vertical integration can be an effective strategy when used prudently. It has the potential to enrich a firm's new product development because it provides the opportunity to integrate tacit knowledge with complementary assets across different value chain activities (Teece, 1986). In technologically advanced industries, where suppliers often

<sup>54</sup> In general, what is an advantage for the one represents a corresponding disadvantage for the alternative.

control vitally important new technology, internalizing these technological capabilities affords control and assures access to the knowledge necessary to build a portfolio of products based on cutting-edge technology (Afuah, 2001).

As opposed to a policy of either vertical integration or complete outsourcing, another alternative is the simultaneous pursuit of vertical integration and strategic outsourcing. This hybrid approach has been termed *taper integration* and describes “when firms are backward or forward integrated but rely on outsiders for a portion of their supplies or distribution” (Harrigan, 1984, p. 643). Taper integration can combine the benefits from vertical integration, such as economizing on transaction costs (Williamson, 1975), with those from strategic outsourcing—such as increased flexibility and access to knowledge and operational best practice external to the firm (Powell, Koput, and Smith-Doerr, 1996). The right balance of vertical integration and strategic outsourcing can enhance a firm’s product portfolio and product success, which contributes to competitive advantage and overall firm performance (Rothaermel, Hitt, & Jobe, 2006).

#### ***4.2. Domestic vs. Offshoring***

Aside from the question of whether activities are done internally or by an outside supplier, what leads firms to develop internal facilities abroad and/or prefer sourcing from suppliers located in offshore locations? In order to make an informed decision to outsource from an offshore supplier, a firm must understand the total costs—expected production and transaction costs, as well as potential added costs due to additional risks—of an offshore project.

The risks and complexities of offshore sourcing can be very large compared with domestic sourcing. These may relate to political atmosphere, tariff barriers, variations in ethical and quality standards, currency exchange rate, cultural and communication obstacles, etc. (Min, LaTour, & Williams, 1994). While a foreign supplier’s production cost levels are likely to be lower, and the quality of its products may or may not be higher, the transaction cost levels related to international transactions are almost always higher (Rangan, 2000).

**Figure 15: Domestic vs. Offshoring**

Domestic Advantages	Offshoring Advantages
<ul style="list-style-type: none"> <li>▪ <b>Decreased Cost:</b> less transaction costs related to geographic (possibly cultural) proximity; Porter’s Cluster Theory</li> <li>▪ <b>Political Pressure:</b> domestic government incentives; satisfy labor union</li> <li>▪ <b>Access Knowledge:</b> if only available domestically</li> <li>▪ <b>Knowledge Management:</b> manage and protect intellectual property (based on laws)</li> <li>▪ <b>Risk Management:</b> reduce operational risks associated with transportation and logistics</li> <li>▪ <b>Knowledge Specialization:</b> develop cluster-based talent pool</li> </ul>	<ul style="list-style-type: none"> <li>▪ <b>Decreased Cost:</b> labor arbitrage</li> <li>▪ <b>Political Pressure / Market Access:</b> foreign governments demands regarding strategic industries</li> <li>▪ <b>Access Knowledge:</b> if only available offshore; includes knowledge of customer</li> <li>▪ <b>Time Zone:</b> seamlessly accomplish sequential task during normal day shift, using different time zones available 24x7; also possible between earth's hemispheres of summer/winter</li> <li>▪ <b>Risk Management:</b> reduce systematic risk due to currency fluctuation, natural disasters, acts of war, terrorism, etc.</li> </ul>

Thus, effective global sourcing strategy is a complex balancing act between numerous relevant factors—lower production costs abroad versus lower transaction costs locally, foreign market access versus local labor interests, capacity investment cost versus erosion of internal knowledge and capacity.

### 4.3. Assessing Cost

Total Cost of Ownership (TCO) is a “purchasing tool and philosophy which is aimed at understanding the true cost of buying a particular good or service from a particular supplier” (Ellram, 1995). It is used primarily for supplier selection and evaluation.

Beginning in the late 1980s, researchers began to advocate management of supplier selection from a total cost standpoint rather than focusing on the purchase price. Monckza and Trecha developed the Supplier Performance Index (SPI), introducing a “non-performance cost” factor to account for additional costs incurred by the purchaser to correct deficiencies related to quality, delivery or price (Monckza and Trecha, 1988).<sup>55</sup>

During the 1990s, a number of authors proposed different variations of a total cost of ownership (TCO) concept.

<sup>55</sup> The Supplier Performance Index (SPI) is a uniform business-wide supplier rating system where past supplier performance on quality and delivery are captured and quantified using an index technique. The SPI formula includes a statistical normalizing method to correct for the basis of large dollar suppliers.

**Figure 16: Total Cost of Ownership (TCO) Approaches**

Author	Year	Approach		
Carr and Ittner	1992	Suppliers' value should be defined in terms of: - cost of purchasing - cost of holding inventory - cost of poor quality - cost of delivery failure		
Smytka and Clemens	1993	Divide total costs into two categories: <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; vertical-align: top;"> <u>External</u>                              - price                              - discount term                              - ordering costs                              - transportation                              - supplier visits                              - tooling                              - technical support                         </td> <td style="width: 50%; vertical-align: top;"> <u>Internal</u>                              - inventory cost                              - delivery expediting cost                              - line down cost                              - non-conformance cost                         </td> </tr> </table>	<u>External</u> - price - discount term - ordering costs - transportation - supplier visits - tooling - technical support	<u>Internal</u> - inventory cost - delivery expediting cost - line down cost - non-conformance cost
<u>External</u> - price - discount term - ordering costs - transportation - supplier visits - tooling - technical support	<u>Internal</u> - inventory cost - delivery expediting cost - line down cost - non-conformance cost			
Ellram	1993	Divide total costs into three categories: - pre-transaction - transaction - post-transaction		

A summary of some of the key benefits of adopting a TCO philosophy are that TCO analysis (Ellram, 1995):

- provides a consistent supplier evaluation tool, improving the value of supplier performance comparisons among suppliers and over time;
- helps clarify and define supplier performance expectations both in the firm and for the supplier;
- provides a focus and sets priorities regarding the areas in which supplier performance would be most beneficial (supports continuous improvement), creating major opportunities for cost savings;
- improves the purchaser's understanding of supplier performance issues and cost structure;
- provides excellent data for negotiations;
- provides an opportunity to justify higher initial prices based on better quality/lower total costs in the long run; and
- provides a long-term purchasing orientation by emphasizing the TCO rather than just price.

It is important to note that none of the organizations studied use total cost of ownership (TCO) tools for all purchases. The use of TCO is reserved for certain items/services where the organization feels that such analysis can provide greatest benefit. TCO tools have proven difficult to apply in practice, and have been adopted by only a limited number of firms. One of the principal barriers is lack of readily available accounting and cost data. This is due the use of traditional cost accounting for allocating costs (Ellram, 1993). Another barrier is the complexity of TCO modeling. TCO costs are often situation-specific, and the relevant cost factors for decision-making vary on the basis of many factors. Finally, the lack of a standardized approach serves as a barrier to broad implementation. TCO models in use vary widely by company, and research indicates that models frequently vary within companies depending on the buy class and/or item purchased (Ellram, 1995).

To overcome these challenges, organizations must employ appropriate metrics to gather required data, develop a simple and standardized TCO approach, and offer user training and education in support of TCO efforts. A cultural change may also be necessary for the firm to move away from a 'lowest price' orientation, towards maximum value / total cost understanding. The need for cultural change is a major reason why TCO is regarded as a philosophy, rather than as merely a tool.

Other approaches have been to combine TCO and activity-based costing to develop a framework that allocates relevant sourcing costs according to the resources consumed by supply chain and purchasing activities (Degraeve, Labro, & Roodhooft, 2005). Also, another method used to inform decision-makers in supplier selection and evaluation is zero-base pricing (or, "should cost" modeling). Zero-base pricing focuses primarily on understanding the supplier's pricing structure and the supplier's cost of doing business (Burt, Norquist & Anklesaria, 1990).

*Life Cycle Costing.* Life Cycle Costing (LCC) is "a way of thinking where attention is paid to the total costs that occur during a product's *entire life cycle.*" (Lindholm and Suomala, 2005). Total costs can be considered in different ways – from the standpoint of the product's supplier/manufacturer or the product's owner or end-user, or even more broadly from the perspective of society as a whole. The concept of life cycle costing

suggests that: a) the total costs of a product can be influenced beforehand, and b) the various cost factors are interrelated.

The premise that total costs of a product can be influenced beforehand has been validated through widespread successful implementation of Target Costing by Japanese firms since the 1960s.<sup>56</sup> Target costing systems first identify the cost at which the product must be manufactured if it is to achieve its profit objective and then create a disciplined environment to help ensure that the target cost is achieved (Cooper and Slagmulder, 1997).

The second basic principle that cost factors are interrelated can be clearly illustrated through a simple example. If a Boeing supplier uses more expensive but lighter materials when manufacturing an aircraft component, it can lead to a significant decrease in airline costs due to lower fuel consumption, plus potential benefit to society by diminishing environmental pollution.

Thus, to achieve global rather than local cost reduction, it is necessary to evaluate how cost factors interact and accumulate among the relevant stakeholders during the different life cycle stages. Furthermore, knowing the life cycle costs of a product is fundamental to considerations of either outsourcing functions or offering capacity for use by other organizations in the value stream (i.e. vertical integration decision-making)

One criticism of LCC is that it may allow under-emphasis of pre-transaction costs, since it may focus users primarily on the costs of purchasing and operating capital equipment or fixed assets.

*Management Accounting.* Financial value analysis for global sourcing must support a goal of making informed business decisions for the *future*. Unfortunately, traditional accounting methods are based on historical estimates and designed to adhere to GAAP accounting standards. This makes traditional cost accounting better suited for mass

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<sup>56</sup> The Japanese approach to target costing appears to have been developed at Toyota in the early 1960s (Monden, 1995). Some even consider Target Costing to be one of the major management practices sustaining the competitive advantage of Japanese enterprises (Koga and Matsuo, 1996).

production rather than “Lean” organizations, as the traditional accounting metrics can frequently contradict the benefit of lean improvements.<sup>57</sup>

A more efficient and pragmatic method known as “Lean accounting” has therefore been created to support process design and improvement. Based on principles of management accounting, no overhead allocation for joint resources is applied within decision-making, since it frequently leads to erroneous insight. Rather, accounting cost considerations are limited to those costs which are “unique,” meaning directly attributable to the activities involved.

#### ***4.4. Risk Management***

Understanding and mitigating risk in the supply chain is vital to architecting a robust network that can ensure a steady stream of inputs and avoid costly disruptions. A careful examination of risks can help screen potential candidate suppliers and help guide the decision of which activities to outsource and which to keep inside the firm. Once specific threats have been listed and prioritized, it is possible to effectively use that risk assessment to help choose suppliers, as well as to design contracts that manage the associated risks.

Recognizing that only a certain portion of risks can be mitigated through contracts, the residual uncontrollable risks are useful to screen which candidate value chain elements are appropriate for outsourcing and which should be kept in house.<sup>58</sup> Seldom well understood or clearly articulated, risks related to strategic outsourcing decisions often create their own problems for both buyer and seller. Buyers’ risks include risk of overpaying, risk of damage to reputation resulting from inferior service, and risk of loss of control over vital assets. On the other hand, sellers’ risks include undercharging as a result of contracting error, as well as other risks.

There are some activities which are strategic by their nature and should not be outsourced. As described by Clemens and Hilmer (1997):

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<sup>57</sup> For example, traditional accounting treats inventory as an asset on the balance sheet. Thus, a reduction in inventory results in reduced net income on the income statement.

<sup>58</sup> Some residual unanticipated risk will always remain. In decision analysis, an “unknown unknown” is an uncertainty that is unanticipated and, hence, unaccounted for in a formal decision model.

In medieval castles the most secure part of the castle, used in time of siege to protect the wealth and the family of the lord of the manor, was termed the *keep*. Those activities that must be protected — those whose loss would result in unacceptable economic damage and, perhaps, to failure of the firm — must be protected and deserve to be placed in the central keep of the firm.

Quinn and Hilmer (1994) suggest that activities which represent core competencies cannot be outsourced and that non-core activities are candidates for outsourcing. Clemens and Hitt (1997) argue, however, that the definition of a core competency has never been clear or unambiguous, and the idea itself can lead to poor outsourcing decisions.<sup>59</sup> Two cases examples which they point to are airline computer reservation systems (CRSs) and aircraft maintenance. Travel agent computer reservation systems would not appear to be part of serving passengers or flying planes, and thus not core to airlines. Yet, some major failures in the airline industry such as PanAm and Eastern (both of which collapsed in 1991) represented airlines which chose not to invest in and develop such non-core systems.<sup>60</sup> Conversely, aircraft maintenance would appear to be a core activity for an airline, without which it would be unsafe to fly. Yet, many airlines safely continue to outsource maintenance from other, larger carriers, such as American Airlines, Lufthansa, and Swiss Air.<sup>61</sup>

Clemens and Hitt (1997) suggest risk-based screens for identifying 'keepers':

*Screen 1:* A firm should consider an activity to be a keeper if the size of the economic loss that can result from an outsourcing contract is too great to absorb and if the loss, should it occur, would destroy the firm.<sup>62</sup>

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<sup>59</sup> If a core competence is thought of as an activity that represents a skill shared by all divisions of a conglomerate, then a core activity can be as much an aspect of corporate culture as it is a skill.

<sup>60</sup> AMR's SABRE and United Airlines' Apollo in the early 1980s were more profitable for American and United than were the business of serving travelers by operating an airline (Clemens & Hitt, 1997).

<sup>61</sup> Clemens and Hitt (1997) note that the risks of outsourcing maintenance service are, paradoxically, much less than the risks of outsourcing reservations service. Alternative providers of maintenance service prevent hold-up, and an airline would switch providers at contract renewal time if its provider attempted to impose unfair charges.

<sup>62</sup> The first screen does not exploit Modern Portfolio Theory or other risk reduction techniques based upon diversification, and thus is extremely conservative.

*Screen 2:* A firm should consider an activity to be a keeper if the size of the expected economic loss that can result from an outsourcing contract exceeds the expected economic gains.

While these screening mechanisms may seem intuitive, applying them in practice is quite difficult. Defining loss is relatively easy. We can define the expected potential loss from outsourcing and activity simply as the magnitude of the exposure times the probability of loss.<sup>63</sup> However, defining all the ways that damage can occur is seldom easy. Exposure includes possible damages, such as overcharges, deliberate under-performance of critical tasks resulting in loss of customer good-will, and others that we have not yet discussed. Likewise, determining the probability of loss likewise is seldom easy, even for those losses that have been identified.<sup>64</sup>

Often when considering outsourcing decisions, most decision-makers have not known how to enumerate expected costs or how to assess their magnitude or their likelihood. Therefore, these rules for guiding outsourcing decisions have not been followed, and *ad hoc* assessments of strategic and non-strategic activities have been the norm.

Specific actions of one party, damaging to the interests of the other, usually fall into one of three categories: shirking, poaching, and opportunistic renegotiation (Clemens and Hitt, 1997). These three categories of risks may impose additional costs upon parties to inter-firm relationships, which are included in the category of costs called transaction costs (see Klein, Crawford, and Alchian, 1978; or Williamson, 1975).

- *Shirking* represents deliberate under-performance on a task that is difficult to measure, while still claiming full payment as if the task had been fully accomplished and had been completed in accordance with agreed upon standards of performance.

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<sup>63</sup> To be precisely correct, in place of expected loss the evaluations should use the smaller of two quantities, either: a) expected loss without any contractual attempt at mitigation of risk; and b) expected loss after contractual risk reduction, less the real costs of the risk reduction mechanisms employed (Clemens and Hitt, 1997).

<sup>64</sup> Many potential sources of loss can be eliminated by effective contracting, other potential sources of loss can be rendered unlikely, but unanticipated environmental changes can create unanticipated opportunities for exploitation that were not protected against in the outsourcing contract.

- *Poaching* represents the theft and subsequent misuse of information or training and expertise, given in trust for the accomplishment of a specific purpose, now used for the gain of the recipient of the information and to the detriment of the giver.
- *Opportunistic renegotiation* becomes possible when either party comes to enjoy an unanticipated increase in power. The party with power can exploit the strategic vulnerability of the other; for example, the client can decide to pay less, or the vendor can demand more.

*Failure Mode and Effects Analysis.* Given the variety of risks inherent to strategic sourcing decisions, firms need to incorporate an effective methodology to systematically rate potential risks relative to each other. The process should enable firms to first recognize those risks with the highest potential impact, and then facilitate actions to reduce or avoid the risk. In most circumstances, firms are forced to accept some level of risk. Therefore, the goal of the organization in risk analysis should be to effectively understand when and how much risk it is accepting, in order to make informed judgments about risk-reward tradeoffs.

Failure Mode and Effects Analysis (FMEA) is a widely used tool within manufacturing industries. First introduced formally by the US Armed Forces in the late 1940s, FMEA was later adopted within the aerospace/rocket industry to avoid costly errors on projects such as the Apollo Space program. Since then, many companies have incorporated FMEA as an effective risk analysis tool related to product design. For example, Toyota has incorporated the FMEA principles within a process it uses called Design Review Based on Failure Modes (DRBFM).<sup>65</sup> In the case of strategic sourcing, it is possible to employ the same fundamental FMEA process toward supply chain design.

In FMEA, failures are prioritized according to how serious their consequences are, how frequently they occur and how easily they can be detected. A FMEA also documents current knowledge and actions about the risks of failures, for use in continuous improvement.

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<sup>65</sup> A comprehensive, well-done FMEA can be considered a prerequisite for a DRBFM; the DRBFM need only be implemented when design changes occur.

- *Step 1: Severity.* List and assign a ‘Severity Rating’ (1 = no danger, to 10 = important) to all failure modes, based on functional requirements and their effects. A failure ‘effect’ is defined as the result of a failure mode on the function of the system as perceived by the user. If the severity of an effect has a number 9 or 10, consider actions to eliminating the failure mode, if possible, or protect the user from the effect.
- *Step 2: Occurrence.* List and assign a ‘Occurrence Rating’ (1 = never, to 10 = certain) for all causes of a failure based on how likely it is to occur. This can be done by looking at similar scenarios and the failures that have been documented for them. All potential causes for a failure mode should be identified and documented.
- *Step 3: Detection.* List and assign a ‘Detection Rating’ to each combination from the previous two steps, based on the ability of planned tests and inspections to detect the failure mode prior to its occurrence.

After these 3 basic steps, a Risk Priority Number (RPN) ranging from a low of 1 to a high of 1000 is calculated for each failure mode and its resulting effect(s).

$$\text{RPN} = \text{Severity Rating} \times \text{Occurrence Rating} \times \text{Detection Rating}$$

Using the RPNs, it is easy to determine the areas of greatest concern. The failure modes that have the highest RPN should be given the highest priority for corrective action. Recommended actions with targets, responsibility and dates of implementation should be noted. These actions can include specific inspection and testing of a potential supplier or their quality procedures, redesign (such as selection of a new supplier), adding more redundancy (maintaining internal production or dual outsourcing) or limiting environmental stresses (slower production ramp-up). Once the actions have been implemented in the design/process, the new RPN should be checked, to confirm the improvements.

The best size for an FMEA team is 4 to 6 people, carefully selected, based on the contribution they can make to the specific FMEA. An FMEA team should represent a cross-section of the company in terms of functional responsibility and level in the organization. Team members should typically come from: Manufacturing, Engineering,

Materials/Purchasing, R & D, Maintenance, Quality, Tech Service, Customers, and Suppliers.

There are a number of common pitfalls related to implementation of FMEA. First, it prioritizes but doesn't correct, which requires someone to act based on the information. Second, the tool is only as good as the team. Third, it is time consuming to get into the details, which demands sufficient time allocation. Fourth, there will always be so called 'unknown unknowns' due to either missing a failure mode or based on an effect outside the experiences of the company. Finally, not including the right people, such as operators, customers, and suppliers, may fail to incorporate otherwise unknown failure modes and an "outsider" perspective that may prove useful in facilitating integration with other systems and continuous improvement.

In Chapter 4, we discussed the tradeoffs of global sourcing alternatives, numerous approaches to assessing cost, and the use of risk management (specifically FMEA analysis) as a methodology to help recognize and develop effective strategies to manage risk in global sourcing. Chapter 5 presents the "current state" analysis of the strategic sourcing decision process within BCA, and proposes a decision-support model to facilitate standardization and support continuous process improvement.

## 5.0 DECISION SUPPORT MODEL FOR GLOBAL SOURCING

*“Modeling is not a one-shot activity that yields The Answer, but an ongoing process of continual cycling between the virtual world of the model and the real world of action.” (Sterman, 2000, p. 89).*

Modeling is the process of representing a system with a model that is easier to understand than the actual system. The model should be clear, comprehensive, and accurate, so that its users can rely on its representation to understand system functionality, analyze its various postures, and predict its future behavior. Capturing important feedbacks is more important than a lot of detail in the specification of individual components (Sterman, 2000, p. 96). Representing the system implies incorporating system elements, relationships, goal, inputs, controls, and outputs.

Effective modeling of a system has two prerequisites: a) understanding the structure of the actual (real-world) system and the functionality and characteristics of each system component and relationship, and b) choosing the appropriate modeling technique for representing the underlying real-world system. Based on budgetary and time constraints, the model should be practically and economically feasible as well as beneficial in meeting the ultimate goal.<sup>66</sup>

Sourcing practitioners often stress the importance of not introducing unnecessary micro-level analysis that would make a model of strategic sourcing scenarios unwieldy and overcomplicated. Instead, to make the model applicable for a wide range of sourcing decisions of varying importance, we will apply a simpler heuristic “rule of thumb” approach as much as possible.

A key component to ensuring alignment of the model output with the desired goal is to define the model’s objective function unambiguously. There is a wide range of possible metrics which BCA could use to evaluate strategic sourcing alternatives. Some examples include: cost, risk, strategic value and opportunities, operational value (e.g. quality, efficiency, flexibility), financial value (e.g. profit, revenue, return on invested

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<sup>66</sup> Expectations from a simulation study should be realistic and not overestimated. Some decision makers think of simulation study as model-building time and cost. Although model building is a critical phase of a simulation study, it often consumes less time and cost than does experimental design or data collection.

capital); or others (e.g. market share, stability of labor employment, defense/industrial offsets, consistency, reduction in total suppliers, manufacturing lead time, etc.).

The right metrics provide a common language for communication and focus employees' attention on what matters most to success. It is the responsibility of company leadership to clearly define performance measures in order to help achieve organizational learning and continuous improvement. Good measures are explicitly defined in terms of owner, unit of measure, collection frequency, data quality, expected value (targets), and thresholds.<sup>67</sup> These measures should monitor the implementation and effectiveness of the strategic sourcing decisions, and determine the gap between actual and targeted performance.

As Shapiro (1984) pointed out, supply chains are all too often seen as cost centers rather than opportunities to create and deliver value. In the last decade, BCA leaders have tended to emphasize accounting-based cost metrics for sourcing decisions (while satisfying standards for quality and delivery). This is very much the traditional "classic view" of supply chain architecting, which has a goal of 'minimizing an objective cost function given a required service level constraint.'

**Figure 17: "Classic" vs. Lean Supply Chain**

	<b>The "Classic" View</b>	<b>The Lean Supply Chain</b>
<b>Focus</b>	Minimize Cost	Maximize Value
<b>Accounts</b>	Only Obvious, Quantifiable Costs & Short-term "Tactical" Risks	True Costs, Tactical & Strategic Risk + Flexibility, Resiliency, & Responsiveness
<b>Degrees of Freedom</b>	4 DOF: # nodes, locations, how to connect them, & intermediate stocks in each	Concurrent Product, Process and Supply Chain Engineering
<b>Supply Chain View</b>	Static	Evolves with Market

Source: Diaz, 2005.

A problem with the "classic" type of cost focus is that frequently only obvious costs (such as transportation and inventory costs) are accounted, while other important

<sup>67</sup> These dimensions are used by the Balanced Scorecard Institute, a Strategy Management Group Company (<http://www.balancedscorecard.org>).

costs are generally ignored because they are difficult to quantify. Supply chain breakdowns, diminished barriers to entry, knowledge loss, or diminished trust from employees over the long term fall into this category. Thus, since minimizing cost does not always equate to maximizing value, our model instead attempts to maximize value as an aggregate function of strategic, operational and financial factors, as well as incorporate relevant risk factors.

### 5.1. “Current State” Decision Analysis

If our objective is to improve the quality of BCA’s sourcing decisions, our emphasis should be on *improving the system*.<sup>68</sup> Thus, our analysis of the current state is focused on understanding the underlying structure of what data is gathered when and by whom, what analysis is performed on the data to derive useful information, and how this information is used to make decisions. One aspect of the structure that is important to understand is the incentive structure which drives the behavior of managers and their employees. Within many organizations, performance evaluation and other reward systems are more-or-less related to profitability. Such incentives often influence rational actors within the system to continuously reduce costs in order to meet stated organizational expectations or achieve higher accounting-based profit margins.

Based on historical documentation and interview data, the strategic sourcing decision process as it currently exists in Boeing strongly emphasizes traditional accounting-based cost factors. Furthermore, evidence indicates that at the detail level analysts and decision-makers employ a non-standard factor approach to cost, benefit and risk analysis. To assess what factors are considered, I examined historical documentation from a sample of three past sourcing decisions—one standard insource-to-outsource work transfer proposal, one work transfer proposal designed in support of increased market access (referred to within Boeing as Strategic Work Placement), and one work transfer proposal designed to fulfill explicit military offset requirements (referred to within Boeing as Industrial Participation).

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<sup>68</sup> Using a systems dynamics philosophy, our focus does not attribute the quality of decisions to any individual or group, but rather the underlying structure of the system.

**Figure 18: BCA "Current State" Cost Factors**

	Case A	Case B	Case C
<b>Recurring Costs</b>			
Material	X	X	X
Labor	X	X	X
<b>Non-Recurring Costs</b>			
Fabrication Division			
Test Prototypes	X		
Mechanic Knowledge Transfer	X		
Process Engineer Support	X		
Manufacturing Engineer (ME) Support	X	X	X
Supply Chain Analyst (SCA) Support	X		
Tool Fabrication Support		X	
Define Engineering Support		X	
Facilities		X	
Quality		X	
Tooling Support		X	X
Shop & other support		X	
Tool Shipping		X	
Technical Support	X		
International Travel	X	X	
Onsite Support	X		
Tool Fabrication Support	X		
Domestic Travel		X	
MOP Foreign Living (Major Outside Production)		X	
Procurement Quality Assurance (PQA)		X	
M&PT Engineering Support	X		
Engineering Support	X		
Tulsa Impact		X	

The figure above depicts some of the many factors that exemplify the variability which exists regarding non-recurring detailed costs for each case. The documentation clearly indicates that a different set of costs are considered in each case. Furthermore, different terminology appears to be used to represent what in actuality may be the same cost. For example, it is unclear what in Case A constitutes "Technical Support" and "Onsite Support", versus what in Case B represents "Shop and Other Support".

There are a number of possible reasons which may explain variance in the documented cost analysis. First, it may be due to different perspectives, levels of experience, or training of personnel tasked with performing the analysis. Additionally, it may be due to one or more factors being irrelevant to the particular case. Another possibility is there may be some hidden agenda on the part of analysts and cost estimators to exaggerate or understate the true anticipated costs.

It is interesting to note, for example, that Case A represented a work transfer proposal in support of market access and cost reduction which originated from *outside* the manufacturing organization performing the work. As such, it was relatively unpopular in the minds of these important stakeholders. Conversely, Case C was a work transfer

proposal which originated from *within* the very same internal manufacturing unit that was currently performing the work. Their objective was to outsource the work in question to free up capacity for newer, more technologically advanced and higher-value work involving new airplane development. In the end, Case A was ultimately denied, while Case C was approved.

With respect to strategic sourcing benefits, costs and risks, the less standardized the decision analysis procedure, the more difficult it is to achieve consistent and objective results. Furthermore, the more difficult it is for higher-level managers to provide effective oversight. From a political perspective, we can imagine that unpopular work transfers may on occasion result in organizational resistance by engineers and analysts exaggerating costs, while popular work transfer proposals may not include all costs which are relevant (e.g. travel, onsite support, etc.).

Furthermore, processes in which decisions are based on unclear metrics and analysis serve to stifle organizational learning and innovation, and often lead to a lack of confidence in controversial decisions. Some solutions may originate solely based on the actions of an individual, with localized goal and objectives. While the benefit of less structured processes are added flexibility and increased ability for individuals to influence the outcome, such processes have large variation in their perceived quality and are very difficult to improve.

In examining the factors not directly related to cost, less documentation exists regarding what was considered and how important these factors were in the ultimate decision. The figure below shows that quality, delivery, schedule, market access, and strategic partnerships were not uniformly or explicitly mentioned in each of the three case examples.

There are a number of reasons why analysts might not document non-cost factors, such as: a) they were irrelevant to the decision (e.g. quality already established as sufficient), b) the factors were evaluated and documented elsewhere, or c) the definition of a factor (or how to effectively evaluate potential suppliers on that dimension) was unclear. For example, how should the value of a potential strategic partnership be estimated, or the potential value of market access? These criteria are not only more vague, they are also less certain than factors related to near-term financial costs.

Ironically, while “soft” factors are more challenging to estimate, they may actually be more significant in affecting the long-term future state.

**Figure 19: BCA "Current State" Non-Cost Factors**

	Case A	Case B	Case C
<b>Non-Cost Factors</b>			
Quality			
Delivery	x		
Schedule	x		
Market Access			
Strategic Partnerships			x
<b>Non-Standard Factors*</b>			
Security Risks	x		
Export Compliance	x		
Submission of the most in-depth RFP response			x
Current supplier			x
Availability of new facilities			x
Availability of increased capacity			x
Supplier development potential			x
No encumbering linkages to JVs			x
Pricing proposal below targets			x

Less apparent emphasis on non-cost factors may also represent insufficient data available or insufficient resources devoted to gathering necessary data. Since much of the business case cost analysis is conducted by personnel from the Finance organization, it is not entirely surprising to find less consideration of other important strategic, operational and risk factors documented.

In summary, there are a number of challenges associated with improving the current strategic sourcing process. To begin with, Boeing may want to consider establishing a more consistent approach, as well as developing a methodology to explicitly integrate difficult-to-quantify “soft” costs with the more straightforward accounting-based financial metrics.

- *Lack of adherence to a standardized detailed process.* The current detail estimation and analysis is *ad hoc* (or, “for this purpose”), based on a vague combination of quantitative and qualitative metrics. A standardized detailed analysis procedure may better ensure the quality of all strategic sourcing decisions, as well as support organizational learning.

- *Integration of qualitative and quantitative factors.* There are a number of non-quantifiable “soft” cost and risk factors that are more challenging to estimate than short-term “hard” financial metrics.

*Organizational resistance to change.* Based largely on our human nature to strongly adhere to the status quo rather than have our long-held beliefs proven wrong, in many organizations there exists a tendency to resist critical analysis and improvement initiatives. This factor plays a role in organizations unconsciously (or consciously) avoiding the collection of data that disproves presently held beliefs, and discounting alternatives which run counter to the organizational inertia. As aptly described by Sterman (2000, p.33):

Defensive behavior prevents learning by hiding important information from others, avoiding public testing or important hypotheses, and tacitly communicating that we are not open to having our mental models challenged. Defensive routines often yield groupthink, where members of a group mutually reinforce their current beliefs, suppress dissent, and seal themselves off from those with different views or possible disconfirming evidence. Defensive routines ensure that the mental models of team members remain ill formed, ambiguous, and hidden. Thus learning by groups can suffer.

Performance evaluation for many managers and employees is based on financial metrics, which means that even if other non-financial factors are more important to maximize the overall value of the system, they will likely be discounted or ignored in favor of accounting-based cost reduction. Over many years, a traditional cost accounting mentality permeated many legacy organizations, which now leads to resistance of non-traditional accounting basis for decisions.

Another obstacle preventing evolution toward more accurate and effective consideration of “true costs” may be the fact that value streams are not well-defined

enough throughout the organization to accurately allocate only unique costs. Therefore, direct labor-based overhead allocation of many joint costs makes the “true cost” of specific internal parts or processes impossible to accurately estimate.

### ***5.2. Strategic, Operational, Financial & Risk Analysis Framework***

The proposed decision-support model considers twenty-one relevant decision factors for strategic sourcing, organized into four categories: Strategy, Operations, Finance, and Risk. For each of the decision factors, a relative expected value (EV) is assigned on a 10-point scale. In our case examples, an EV of -5 indicates strong advantage for an domestic internal supplier, 0 = no preference, and +5 indicates a strong advantage for an offshore outsource supplier.<sup>69</sup> Based on the pre-determined importance of each factor, the assigned percentage is simply multiplied by the expected value and summed.<sup>70</sup> In this way, the simple weighted average serves to integrate and synthesize the factors.

It is important to note that while the single numerical output provides *support* for one sourcing alternative over another, the number is not intended as sufficient justification for that choice. Rather, the focus of the model is to offer a clear and unambiguous representation of the input factors and their relative importance. This tool should then be useful for decision-makers to clearly recognize and understand the reasons in favor of each sourcing alternative, as well as the risks and leverage points for improving the effectiveness. Through establishing a clear record of the critical sourcing factors and their expected effect, the model also establishes a “snapshot” for later reflection on what was accurately forecasted versus what was missed, misunderstood, or inaccurately represented during the decision-making process. Thus, the model should enable organizational learning and reduce the chances of making the same mistake again.

In order to begin with the most important considerations and counteract the tendency to emphasize financial accounting factors, the first level of analysis to be conducted is the strategic analysis, followed by an operational analysis. Only then, if a

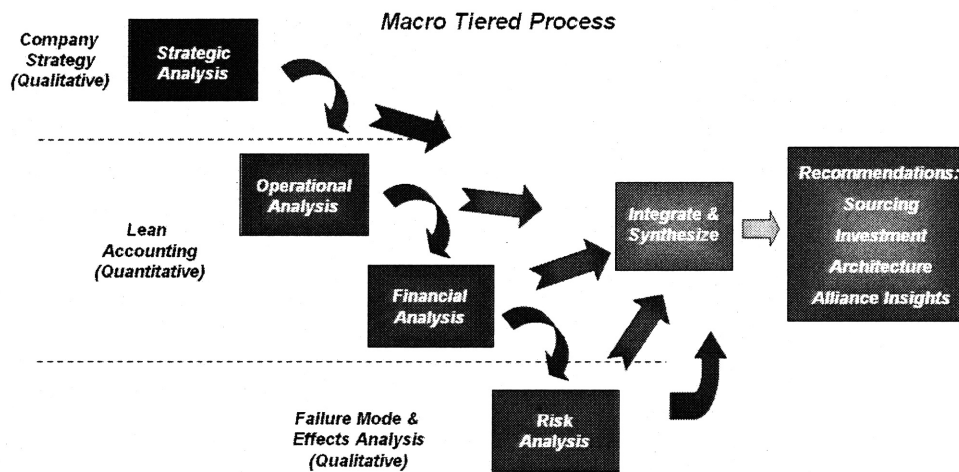
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<sup>69</sup> The model can be used similarly to compare two internal supplier alternatives, two outsource supplier alternatives, or any other combination.

<sup>70</sup> While there are inherent limitations to this methodology, it was chosen based on its simplicity and ease of use, as compared to more complicated techniques which incorporate probability distributions, Monte Carlo simulations, etc.

proposed sourcing alternative satisfies these hurdles, should the financial dimension be considered.<sup>71</sup> The financial analysis should then incorporate the relevant unique costs that relate to each sourcing alternative. Finally, a detailed risk analysis provides insight into the most significant risks to the enterprise, in order to develop a risk avoidance and mitigation plan. The following figure depicts the general structure and order of analysis:

**Figure 20: Integrated DSM for Global Sourcing**



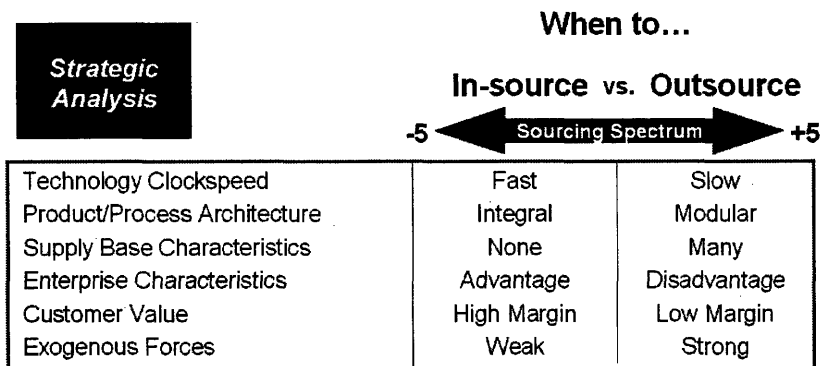
To begin with, our strategic analysis seeks to qualitatively assess the near-term and long-term benefits, opportunities and costs of two sourcing alternatives. In his paper titled *Moving a Slow-Clockspeed Business into the Fast Lane: Strategic Sourcing Lessons from Value Chain Redesign in the Automotive Industry*, Fine (2001) suggests a strategic value analysis which involves: a) Customer Importance, b) Technology Clockspeed, c) Competitive Position, d) Supplier Capability, and e) Architecture. Building upon his work, I explicitly introduce supplier willingness to integrate, enterprise knowledge management, and economic contribution within the third, fourth and fifth dimensions, respectively. Furthermore, I add a sixth dimension titled “Exogenous Forces,” and reorder the steps to align with the value stream construct presented earlier—

<sup>71</sup> For example, it is irrelevant that a particular supplier might offer significant cost savings if the proposed work is core knowledge upon which the firm’s competitive advantage lies. Similarly, the cheapest vendor offering the most cost savings would not be a good alternative if it is unable to meet the minimum quality and delivery requirements.

understand the core technology, align the product/process/supply chain architecture, and deliver measurable value to the customer.

The strategic value analysis, therefore, consists of six components, as detailed below.

**Figure 21: Strategic Value Analysis**



- I. **Technology Clockspeed.** *Clockspeed (Fast vs. Slow).* How rapidly is the underlying technology for this product<sup>72</sup> changing? This relates specifically the rate of technological innovation. *Novelty (Innovative vs. Established).* How new is the underlying technology for this product?
  
- II. **Product/Process Architecture.** *Modularity (Integral vs. Modular).* How integral (number of interfaces) or modular is this product to the overall product, service or system of which it is a component? The more integral the product to the overall system, the more risky to be fully dependent on an outside supplier. *Complexity (Complex vs. Simple).* How complex (number of subcomponents and level of technology required to produce) is this product? The more complex the product, the more knowledge necessary to deliver it and the more valuable to insource.
  
- III. **Supply Base Characteristics.** *Capability (None vs. Many).* How deep and capable is the outside supply base for outsourcing this product? The more capable the supply base (in number of viable suppliers and their technological

<sup>72</sup> The term 'product' as I refer to it within the model may also be substituted with 'service.'

competency) the safer to outsource. In addition to supplier physical and resource capacity, this factor should include management capability, information systems, historical performance, qualifications, as well as any regulatory constraints.

*Supplier Power (Strong vs. Weak)*. How strong is the supplier position for this product? How likely is the chance of supplier hold-up?<sup>73</sup> *Supplier Integration (Close vs. Far)*. How willing and able is the supplier to tie in closely with us, their customer? This relates to general supplier philosophy toward relationships and process improvement, as well as willingness to work closely together and co-locate facilities when appropriate.<sup>74</sup>

**IV. Enterprise Characteristics.** *Enterprise Knowledge (Core vs. Peripheral)*. How core is the knowledge relating to the product to the current or future success of the business? *Competitive Position (Advantage, Disadvantage)*. How capable is the firm relative to its competition in achieving cost, quality, delivery, etc. for this product? This factor should include consideration of core competencies, proprietary technologies, intellectual property, and enterprise value stream alignment.

**V. Customer Value.** *Economic Contribution (High Margin vs. Low Margin)*. How valuable is this product to the customer? The more valuable, the more desirable to keep in house. A quantifiable metric which may be used to represent the value customers apply to a product is economic contribution.<sup>75</sup> This metric depicts the fraction of unit revenue which contributes to offsetting fixed costs, which is a useful measure of the value to the firm for each unit produced internally.

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<sup>73</sup> Consideration of supplier hold-up should include labor unions as a source of labor input, and the potential for strikes or other collective bargaining issues.

<sup>74</sup> As a foundation of Porter's Cluster Theory, geographic co-location is a key factor related to successful integration of material and labor inputs, knowledge sharing and innovation, and effective customer feedback loops.

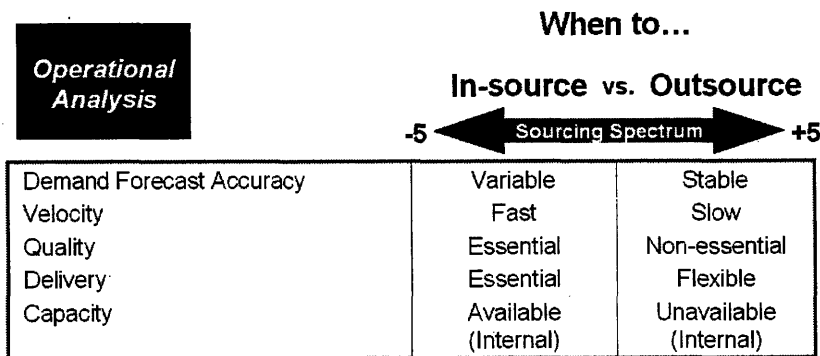
<sup>75</sup> Within managerial accounting practice, *economic contribution* is defined as the unit revenue (market price) minus unit variable cost (i.e. the marginal profit per unit sale).

*Customer Preference (Important vs. Unimportant)*. How does the sourcing option affect customer preferences?<sup>76</sup>

**VI. Exogenous Forces.** *Foreign Market Access (Low vs. High)*. How valuable is the anticipated direct impact of the sourcing alternative on foreign market opportunities? The stronger the foreign market forces relative to the domestic forces, the more desirable it is to offshore and/or outsource products. *Political Forces (Weak vs. Strong)*. How strong are foreign or domestic political forces in relation to alternative sourcing options? This should include consideration of existing and anticipated defense and commercial offset obligations.

For the second phase of our analysis, we begin the operational value assessment by determining the demand forecast accuracy. (Note that this factor is independent of the sourcing alternatives being considered.) The two sourcing alternatives are then compared against each other and assigned a relative value along each of four key operational dimensions (Velocity, Quality, Delivery and Capacity).

**Figure 22: Operational Value Analysis**



**VII. Demand Forecast Accuracy.** (*Variable vs. Stable*). How close is the actual product demand to the forecasted quantity? The more variable the demand signal

<sup>76</sup> Fine (1998) suggests that the more important the source to the consumer, the more important the sourcing decision. However, in light of high customer satisfaction with companies such as Apple who outsource all production, perhaps customers consider the *who* unimportant if their expectation of quality is satisfied.

and inaccurate the forecast, the more desirable it is to source locally and/or insource. This is because delays within the system combined with inaccurate forecasts (often due to unpredictable variable demand signals) will result in greater inventory holding costs necessary to achieve a requisite service level (due to the “bullwhip effect”). It is often valuable, therefore, to maintain short shipping lead times to reduce delays in the system.

The variable commonly used to measure demand forecast accuracy is Mean Absolute Percent Error (MAPE), which is the average of the absolute percentage differences between the actual and forecasted demand data.

$$MAPE = \frac{\sum_{t=1}^n \frac{|Forecast_t - Actual_t|}{Actual_t}}{n}$$

**VIII. Velocity.** (*Fast vs. Slow*). How fast does (or would) the product flow through the supply chain? Commonly measured using its inverse, ‘dock-to-dock time,’ it is defined as the time from when the oldest component and/or raw material (often based on date stamp) arrives at the factory until the completed (sub)assembly arrives at the next downstream customer. Note that this includes time for shipping to the downstream customer. Dock-to-dock time is typically calculated as:

$$\text{Dock - to - Dock Time} = \frac{RM + WIP + FG}{ASR}$$

where

*RM* = raw materials inventory (\$)

*WIP* = work in process inventory (\$)

*FG* = finished goods inventory (\$)

*ASR* = average shipping rate (\$/timeperiod)

**IX. Quality.** (*Essential vs. Non-essential*). How important is quality for this product? The more essential quality is for this product, the more risky it is to be dependant upon an unproven supplier. Defined and measured as ‘defective parts per million’

(DPPM), this factor can first serve as a screening criteria to ensure unqualified suppliers are identified. Frequently, the quality standard will be met by either alternative, however in some instances this is not the case.<sup>77</sup>

This factor can also be useful to incorporate anticipated cost of quality differences between the two sourcing alternatives. In those circumstances, the quality factor should relate the effects of lower quality and new supplier learning curves, if possible through direct cost estimates for helping a supplier attain the necessary standard.

**X. Delivery.** (*Essential vs. Flexible*). How important is delivery of this product, measured as ‘percent of shipments delivered on or before due date’? The more essential on-time delivery is for this product, the better it is to co-locate the supplier with the customer. Like quality, this factor can serve as a screening criteria, since delivery is an important element within lean production systems which require low-inventory and consistent just-in-time delivery.<sup>78</sup>

**XI. Capacity.** (*Available vs. Unavailable*). How sufficient is the supplier’s current available capacity, measured as ‘percentage utilization of key resource constraint(s)’? The fixed cost associated with using excess internal capacity is effectively zero. Thus, this element relates to the cost and time estimated to develop new capacity, and the potential value of additional capacity for future production flexibility.

For the third phase of our analysis, the financial value is specifically intended as a high-level presentation of the relevant financial costs to the organization, for the purpose of decision-making. Due to the weaknesses inherent to allocation-based costing, this analysis incorporates only direct production costs (not burdened by overhead). It also

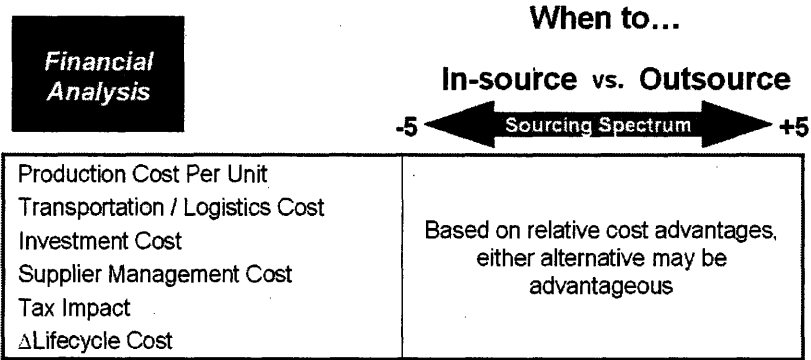
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<sup>77</sup> As an extreme example, interviews with Boeing employees depicted lack of quality on the part of a new offset-related supplier to result in wholesale scrapping of large quantities of parts.

<sup>78</sup> Although contrary to ‘lean principles’, the delivery standard can usually be met by any supplier willing to incur holding costs for locally-warehoused finished goods inventory. While not immediately charged as a direct cost to their customer, there is “no free lunch.” Eventually, excess inventory held anywhere within the value chain will ultimately result in added cost to the consumer and should be eliminated.

seeks to more explicitly estimate transaction costs as part of supplier management costs. Furthermore, by taking a more holistic perspective incorporating indirect lifecycle costs potentially incurred by other value stream stakeholders, the intent is to recognize how a sourcing alternative may impact the costs to other members within the value stream. Note that for all of the financial factors listed below, the lower the *relative cost* of either supplier, the more desirable it is compared to the other.

**Figure 23: Financial Value Analysis**



**XII. Production Cost per Unit.** The sum of all direct recurring material and labor costs divided by the number of units. When data is available, forecasts may be adjusted to account for wage growth rate, labor productivity, and learning curve effects.

**XIII. Transportation / Logistics Cost.** The sum of all recurring<sup>79</sup> costs for movement and storage of material inputs and finished goods, including: transportation, receiving, inspection, inventory holding (both capital charges and warehousing costs), insurance, etc.

**XIV. Investment Cost.** The sum of all *non-recurring* costs related to a sourcing alternative. This includes infrastructure development, supplier selection and negotiation, tooling, manufacturing, facilities (PP&E), labor recruitment and

<sup>79</sup> Note: any non-recurring transportation or logistics infrastructure development costs should be incorporated into 'investment cost'.

training, information technology (IT) and computing, transition support team assistance (from supplier management, engineering, tooling, manufacturing, and other organizations), impact of residual supply from previous supplier, etc.

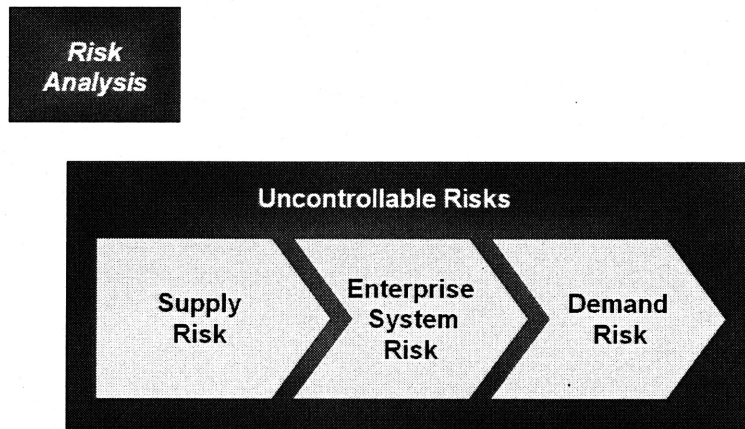
**XV. Supplier Management Cost.** The sum of all recurring costs for managing supplier relationships, including: supplier communication (phone calls, faxes, and video conferences for meetings, forecast updates, performance reviews, etc.), company support personnel working at the supplier location, local hires, recurring supplier training and technical support, quality assurance audits, cooperation with supplier for engineering changes and innovation, renegotiation, etc.

**XVI. Tax Impact.** The sum of all government-related costs and incentives, including: tax and duties (including credits), job training subsidies, other state or federal aid (cost mitigation), discount term, benefit from payment term changes, etc. This factor may be either positive or negative, depending on the location and potential incentives offered.

**XVII.  $\Delta$ Lifecycle Cost.** How do cost factors interact and accumulate among the relevant stakeholders during the different life cycle stages?

As the last component of the model, the detailed risk analysis is subdivided into four categories: supply/dependency risk, enterprise system breakdown, demand uncertainty, and uncontrollable risk. The first three encompass all controllable risks that are endogenous to the value chain, while the fourth considers uncontrollable risks that exist due to changes in the external environment. All four of these broad categories are first considered from the point of view of the firm.

**Figure 24: Risk Analysis Framework**



This model suggests an approach to risk analysis for strategic sourcing that does not mandate a *quantified basis* for all potential risks, since the level of complexity and uncertainty can lead to unwarranted confidence in the estimate. For example, rather than trying to estimate the accurate probability that Russia will experience a dramatic political shift and nationalize Boeing’s investment in the country, we should instead focus on recognizing if the risk exists and developing an effective mitigation plan based on the relative significance of the risk (as determined via FMEA analysis Risk Priority Number). People usually recognize that a qualitative estimate is basically a guess, and are therefore more likely to keep it in the appropriate mind frame.

There are, however, factors which particularly lend themselves to data-driven estimation (such as production or transportation/logistics costs) and risk analysis (such as the probability of earthquakes in a given location based on Bayesian inference models<sup>80</sup>). This is because, while some factor outcomes may be random, there is sufficient data upon which to statistically base an estimate.

**XVIII. Supply Risk.** This category includes any controllable risk which could result in overdependence on suppliers, delays, disruptions, or increased costs of supplier inputs. These can include: knowledge dependence, supplier upstream vertical

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<sup>80</sup> Bayesian inference is statistical inference in which evidence or observations are used to update or to newly infer the probability that a hypothesis may be true. The name “Bayesian” comes from the frequent use of Bayes’ theorem in the inference process.

integration, supplier labor disputes, deliberate underperformance (or “shirking”), opportunistic renegotiation (or “assertion”), moral hazard, capacity dependence, poor quality/rework/scrap, inadequate capability or misrepresentation, supplier inflexibility, single source dependency, inventory holding, logistics and transportation, supplier bankruptcy, etc.

Additionally, risks from the perspective of the supply base should also be recognized, to include relationship-specific investment, winners curse/bid too high, etc.

**XIX. Enterprise System Risk.** Risks associated with the enterprise systems are represented within this category. These include: internal labor disputes, intellectual property breaches (or “poaching”), Information Technology systems breakdown, etc.

**XX. Demand Risk.** This category incorporates any risks from the demand side. Specifically, this may include: inaccurate demand forecast, customer bankruptcy, etc.

**XXI. Uncontrollable Risk.** Lastly, this category encompasses all uncontrollable risks. These can include: natural disasters, acts of war or terrorism, legislation or regulation, financial recession, transportation capacity and pricing, raw materials availability and pricing, exchange rate fluctuation, industry-wide capacity, etc.

In order to test the proposed model’s validity and usability, we will now compare and contrast two examples of Boeing global sourcing decisions as illustrative case studies.

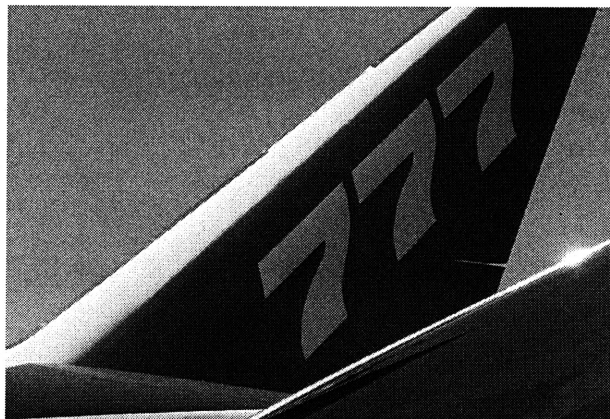
### ***5.3. Application of the Model***

In the first example, production of 737 vertical fins, Boeing has chosen *offshore outsourcing* from two different suppliers. However, for 777 vertical fins, Boeing decided to *locally insource* production at the Boeing Fabrication division. What factors may have

driven the decision to use two very different sourcing strategies for the vertical fins on these two airplane programs? Are there other considerations which decision-makers should consider in the future? To begin with, we will define what a vertical fin is, and how the two different vertical fins compare.

A vertical fin assembly (a.k.a. “vertical stabilizer” or “vertical tail”) is an elliptical airfoil comprised of the leading edge, center box, trailing edge and rudder. It is most commonly a part of the aft end of the fuselage, and points straight upward. The function of the vertical fin flight control surface is the same for both airplanes—to control yaw (i.e. side-to-side horizontal movement) of the airplane while in flight. For both airplane programs exactly one standard vertical fin is required, which means the vertical fin demand forecast is closely correlated to the airplane demand forecast.

**Figure 25: Vertical Fin**



Source: Boeing.com

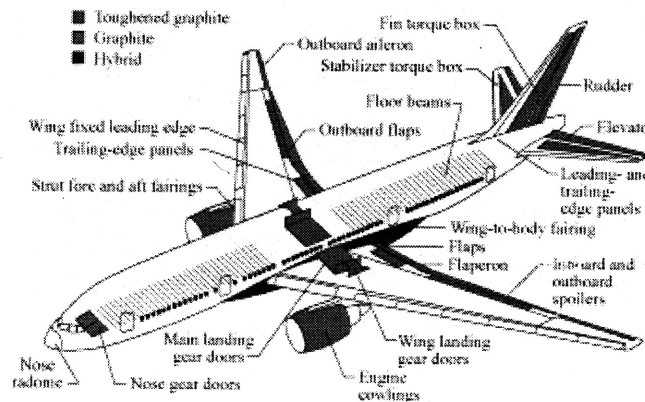
Beyond these general similarities, there are a number of important differences between the vertical fins for the respective programs, some of which are crucial to understand and consider when selecting an appropriate sourcing strategy. As we will see by contrasting these two examples, material / process technology, enterprise knowledge management, foreign market access, and defense offset obligations justify different choices for global sourcing.

#### 5.4. 777 Case Study: Local Internal Sourcing

The Boeing 777 vertical fin is comprised of Carbon Fiber Reinforced Plastics (Fawcett, Trostle, & Ward, 1997), which makes it more technologically advanced than the aluminum 737 vertical fin currently in production. Back in the early 1980s, Boeing first developed its knowledge for manufacturing and testing composite flight control surfaces through a joint NASA/Boeing research program for manufacturing composite empennage (vertical fin, horizontal stabilizer, elevator and rudder) components.<sup>81</sup>

Building on this knowledge, Boeing implemented a company-funded program to construct a 777 prototype/pre-production horizontal stabilizer out of composite materials. The design was based on the 767 design, which engineers adjusted accordingly to achieve the 777 scale while using composite materials (Fawcett *et al.*, 1997). The use of CFRP on the 777 program has since enabled Boeing to continue to develop advanced composite technology for use on subsequent commercial airplane programs such as the new 787 Dreamliner.<sup>82</sup>

**Figure 26: Composite Material on the 777**



Source: NASA, 2003.

Through the proposed decision support model framework, we can now explore what characteristics of the 777 vertical fin are relevant to consider when deciding where to source it. As described earlier, I evaluated all factors on a 10-point scale from -5 to +5.

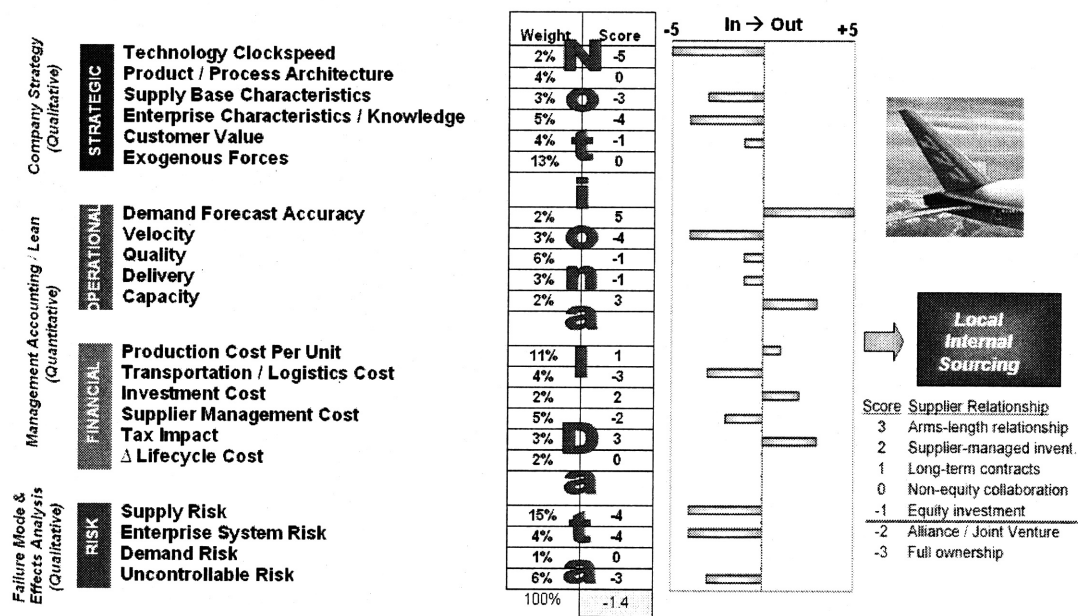
<sup>81</sup> Ironically, the NASA/Boeing 737 horizontal stabilizer still being manufactured out of aluminum was actually the first major component of composite structure certified for commercial use (McCarty, Johnson & Wilson, 1982). Boeing introduced five shipsets of the composite 737 parts into service in 1984.

<sup>82</sup> Carbon fiber reinforced plastic (CFRP) is the primary composite for the majority of the new Boeing 787 Dreamliner's structure, with titanium graphite composites also integrated into the wings (Walz, 2007).

I assigned expected values myself to merely demonstrate application of the model, with relative weightings based on senior leader priorities as expressed in interviews.

The application of the model toward the case examples is strictly to illustrate *how the model would function* to support standardization, unambiguous communication of factor weightings among stakeholders, and documentation of relative sourcing advantages or disadvantages. Thus, there may be legitimate arguments that one or more of the factor weightings or relative advantages should be adjusted—this type of structured interaction to consider all relevant factors, through deliberation among a cross-functional team of stakeholder representatives, may be one of the best ways to achieve a high quality decision outcome.

**Figure 27: 777 Summary Analysis**



As shown in the summary analysis, the weighted average of the twenty-one factors I considered equals -1.4. As a negative number, the output supports the *local insourcing* alternative as the more effective strategy for 777 vertical fins (compared to an offshore outsource supplier). This result is based primarily on aspects of knowledge management which relate to three factors: technology clockspeed, supply base characteristics, and enterprise characteristics. Furthermore, based on these factors, the justification for insourcing is especially strong during the early stages of composite wing technology development.

The model's structure incorporates some relative benefit for geographic proximity, based on greater velocity, and reduced cost of transportation and logistics for a co-located supplier (especially for large structures). Additionally, there is some benefit attributable to reduced supply risk and enterprise breakdown. Since the output is not -3 or less, its relative position along the sourcing spectrum further suggests that once the technology becomes more established and supplier capability improves, at some point an alliance or joint venture may be appropriate.

**I. Technology Clockspeed: (Score: -5 strongly supports local insourcing)**

*Clockspeed.* The underlying technology for composite aero structures is still quickly evolving as firms apply composite materials and process technology in ever increasing percentages to new airplane programs. The unprecedented use of composites for the 787 and A380 shows the importance of this technology to the industry, and finding ways to decrease manufacturing lead time and reduce costs will remain a priority. Furthermore, potential advances may exist for significantly improving the manufacturing processes for composite airplane structures, which Boeing may benefit from investing in itself. *Technology novelty.* The underlying technology for small composite material structures is not particularly new or complicated. For example, light sport aircraft manufacturers are able to construct small composite aircraft in their garage with simple and inexpensive tooling. However, the capability to produce *large-scale composite aero structures* is very new. One example of this would be Boeing's cutting-edge technology for the 787 which offers protection against lightning strikes—a new proprietary design feature.

**II. Product/Process Architecture: (Score: 0 indicates equal advantage)**

*Modularity.* Compared to the 737 aluminum structure, the 777 composite vertical fin interfaces with the overall airplane in much the same way. In both cases the interfaces are well-defined. *Complexity.* The process complexity of the 777 vertical fin is greater because it involves more precise tolerance for the manufacturing environment and employs automated composite lay-up technology.

Conversely, the 737 aluminum manufacturing process is more established process technology and therefore less complex.<sup>83</sup>

**III. Supply Base Characteristics: (Score: -3 supports local insourcing)**

*Capability.* An outside supply base for outsourcing large-scale composite aero structures did not exist in the early 1980's when BCA first developed the capability. While still relatively small, the number of suppliers with such capability is growing—as evidenced by an external supplier chosen to manufacture the composite wing for the 787. *Supplier Power.* Through use of an internal supplier, there are no issues related to supplier power. Conversely, given the limited supply base, a sole source contract would involve accepting the risk of supplier holdup. *Downstream relationships.* BCA Fabrication division is very willing and able to tie in closely with their customer. Boeing's Composite Manufacturing Center (CMC) in Auburn is located within ninety minutes of final assembly in Everett, Washington.

**IV. Enterprise Characteristics: (Score: -4 strongly supports local insourcing)**

*Enterprise Knowledge.* The development and maintenance of composite manufacturing technology is greatly reinforced by sourcing internally.

*Competitive Position.* BCA is among the best in the world in achieving cost, quality, delivery, etc. for designing and producing large-scale composite aero structures.

**V. Customer Value: (Score: -1 mildly supports local insourcing)**

*Customer Preference.* Quality-assured flight control surfaces are very important to customers, particularly at the time when CFRP use in aero structures was a nascent technology. Boeing in-house design and production of composite vertical fins offered customers a greater sense of confidence in the quality and safety of the product. *Economic Contribution.* The reduction in weight associated with the

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<sup>83</sup> Another interesting question indirectly related, is what knowledge of the detailed automated composite process tooling technology is actually within the firm and what is provided by a tooling supplier?

composite vertical fins (versus the previous aluminum structure) results in a corresponding increased willingness of customers to pay a premium price. The market price minus the direct material and labor cost for a composite 777 vertical fin is therefore greater than if it were aluminum. Hence, the economic contribution of the composite vertical fin is more valuable to the enterprise than the 737 vertical fin.

**VI. Exogenous Forces: (Score: 0 indicates equal advantage)**

*Foreign Market Access.* At the time when the sourcing decision was made, no foreign market forces appeared to factor in to the decision. *Political Forces.* No defense offset obligations were sought to be met through outsourcing of the 777 vertical fins. On the contrary, domestic labor relations were strengthened by investing internally in the capability and knowledge of BCA Fabrication through establishment of the CMC center of excellence for composite manufacturing technology.

**VII. Demand Forecast Accuracy: (Score: 5 strongly supports offshore**

**outsourcing)** Demand forecast accuracy is very high, since there is only one model of fin and one vertical fin goes on each respective airplane.

**VIII. Velocity: (Score: -4 strongly supports local insourcing)**

Assuming roughly equivalent manufacturing lead time, the velocity of sourcing from a local supplier is significantly faster, since shipping lead time must be added to an offshore outsource supplier's dock-to-dock time. This would add approximately 40 days to the total lead time if the 777 vertical fin was manufactured, for example, in the Far East.

**IX. Quality: (Score: -1 mildly supports local insourcing)**

Measured as defective parts per million (DPPM). The quality of the internal Composite Manufacturing Center is world-class, and easier to control through an internal supplier organization.

**X. Delivery: (Score: -1 mildly supports local insourcing)**

Delivery is consistently near 100% due in part to the geographic proximity as well as effective management of a just-in-time delivery system.

**XI. Capacity: (Score: 3 supports offshore outsourcing)**

The CMC facility in Auburn, Wash. as it currently exists is operating at a very high level of capacity utilization since being tasked to produce the 787 Dreamliner vertical fins as well as the 777 vertical fins. Thus, on this dimension the cost of additional capacity could involve large fixed costs and lead time related to construction of an expanded facility.

**XII. Production Cost per Unit: (Score: 1 mildly supports offshore outsourcing)**

Sourcing from a lower cost labor regions would result in some variable cost reduction, and therefore make offshoring an appealing alternative. Due to the high level of automation in the composite manufacturing process as currently designed, however, the variable production cost per unit is largely a function of materials cost. Thus, any cost advantage related to labor rate savings would be a relatively small percentage of the total variable production cost.

**XIII. Transportation / Logistics Cost: (Score: -3 supports local insourcing)**

The geographic proximity between Auburn and Everett, Wash. results in very low costs for transportation, inventory holding, and insurance. There was no requirement for non-recurring investment in infrastructure to support the transportation.

**XIV. Investment Cost: (Score: 2 supports offshore outsourcing)**

There were significant investment costs required for Boeing to develop the CMC production capacity for the vertical fins, including direct tooling and facility construction. These costs would not be incurred if the decision were to outsource.

**XV. Supplier Management Cost (Score: -2 supports local insourcing)**

Based on interviews with 777 empennage line managers, a very good internal supplier relationship is facilitated mainly through periodic meetings and phone calls. The level of cooperation between the CMC and downstream internal customer is very close and results in outstanding communication across organizations. When changes are needed, the level of responsiveness was described as excellent.

**XVI. Tax Impact: (Score: 3 supports offshore outsourcing)**

Various incentives would likely be available from foreign governments as an incentive to locate production there.

**XVII.  $\Delta$ Lifecycle Cost: (Score: 0 indicates equal advantage). Unknown.**

**XVIII. Supply Risk: (Score: -4 strongly supports local insourcing)**

Some risk of union labor striking does exist. However, this would have marginal impact if final production was equally affected. More significant risk of limited internal capacity, which could result in delays if rates increase significantly.

**XIX. Enterprise System Risk: (Score: -4 strongly supports local insourcing)**

Very low risk of breakdown for Information Technology systems and Intellectual Property controls, due to commonality of systems and secure intra-firm relationship.

**XX. Demand Risk: (Score: 0 indicates equal advantage)**

Not applicable, since this relates to customer risks which are identical for both alternatives.

**XXI. Uncontrollable Risk: (Score: -3 supports local insourcing)**

Some risk of natural disasters such as earthquake in the Puget Sound region. Additionally, there is risk of financial recession and exchange rate fluctuation based on US currency exposure.

### ***5.5. 737 Case Study: Offshore Outsourcing***

The Boeing 737 vertical fin is made of aluminum, similar in process to the way airplanes have been built since WWII, and comparatively less advanced than composite 777 vertical fin technology. Over the last twenty years, Boeing has increased the percentage offshore outsourcing of 737 vertical fins from 0 to 100%, with incremental decisions to increase outsourcing made in 1989, 1995, and 2003.<sup>84</sup> This increase has resulted partly from expanding military offset requirements by many foreign governments, and also from pressure by foreign governments to offer work to their national aerospace industry indirectly.

Boeing and other commercial airplane makers typically use work placement (in Boeing this is referred to as “strategic work placement” to help develop foreign markets for airplanes, develop sources of production, and motivate future sales. World Trade Organization rules mandate that this strategic work placement is not a condition of sale, so strategic work placement is used to support longer-range strategic objectives.<sup>85</sup>

In 1988-89, Boeing began sourcing empennage components from China when it awarded Xi'an Aircraft Company (XAC) a contract to produce Boeing 737 Classic vertical fins and horizontal stabilizers. The following year, China placed one of the largest commercial aircraft orders in Boeing history: 36 airplanes and 36 options resulting in a purchase totaling \$9 billion.

In 1995, with the introduction of the 737 Next Generation (NG), Boeing contracted with XAC and Shanghai Aviation Industrial Corporation (SAIC) to supply vertical fins and horizontal stabilizers, respectively. This strategic decision allocated some 737 empennage work between two different suppliers and countries while

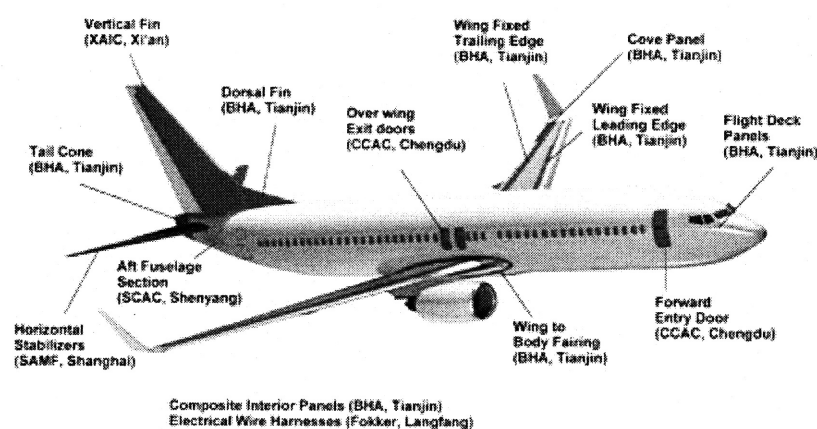
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<sup>84</sup> As of 2007, all 737 vertical fins and horizontal stabilizers are sourced from China and Korea.

<sup>85</sup> Strategic Work Placement also includes placing work in order to access strategic technological capability, such as engineering work done at Boeing's Moscow Design Center.

maintaining a percentage of the work internally at Boeing's Wichita facility (now Spirit AeroSystems), to effectively mitigate some risks inherent in sole sourcing and offshoring.

**Figure 28: China's Role on the 737**



Source: Boeing.com

As noted by some Boeing employees, the first one hundred ship-sets within any airplane program are typically when significant challenges are encountered, along with significant learning and improvement. Thus, after the first couple years a very stable system is normally established and the level of problems diminishes to a point that supplier capability (whether internal or outsource) becomes very good. In the case of the 737 vertical fin, after nearly a decade XAC was very capable as a consistent and quality-assured supplier, having delivered its 1000<sup>th</sup> 737 vertical fin to Boeing in 2004.<sup>86</sup>

In 2002, Commercial Airplanes agreed to help Boeing IDS by fulfilling an offset obligation related to the sale of 40 F-15K aircraft to Korea.<sup>87</sup> In exchange for offset credits, Boeing announced in late 2003 that production of vertical fins and horizontal stabilizers would be outsourced to Korea Aerospace Industries (KAI). Consequently, Boeing decided at that time to completely phase out production of these parts in Wichita. By mid-2005, Boeing announced its decision to also substantially increase 737

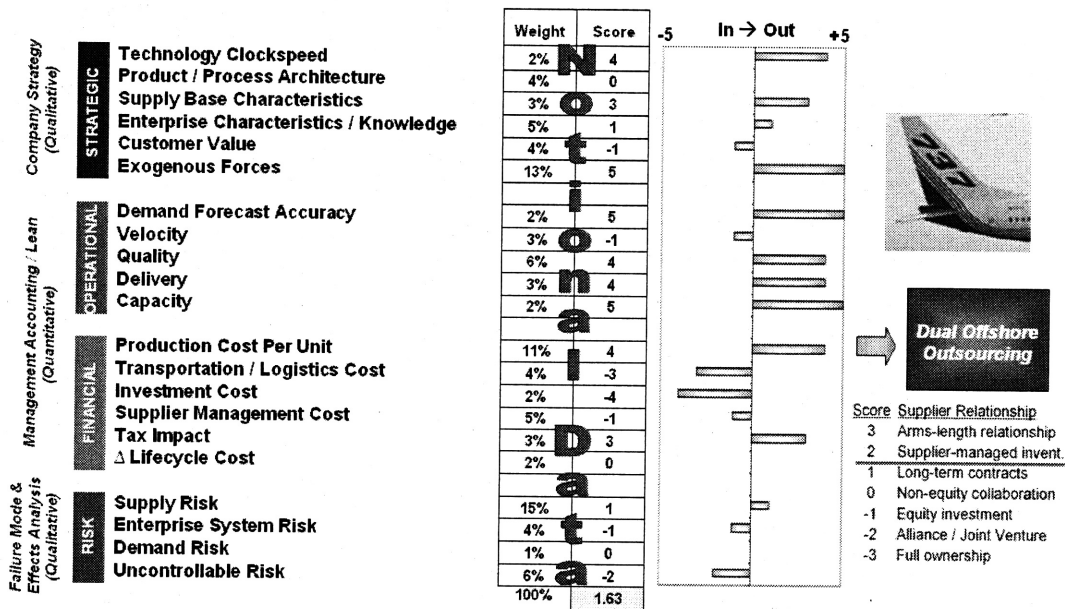
<sup>86</sup> From <http://www.boeingchina.com/en/aboutboeing/chronology.shtml>.

<sup>87</sup> The \$3.3B value of the Boeing-South Korea F-15K offset agreement amounted to roughly 70% of the total \$4.4B sale (Wayne, 2003). Of this \$3.3B, approximately \$1.3B (40%) involved 11 parts contracts such as for commercial airplane parts (Blue Sky Management Consultants, 2004).

component production rates at XAC and SAIC for the vertical fin and horizontal stabilizer. Since 2007, vertical fins and horizontal stabilizers are no longer manufactured in Wichita.

By applying the decision support model framework, we can explore what characteristics of the 737 vertical fin should be considered when deciding where to source it.

Figure 29: 737 Summary Analysis



As indicated in the summary analysis, the weighted average of the sample of factor inputs I considered is +1.63. As a positive number, the output supports *offshore outsourcing* as an effective strategy for 737 vertical fins (compared to local insourcing). This result is based primarily on exogenous forces, sufficient supply base capacity and capability, and more mature technology. This output also suggests a supplier-managed inventory strategy, which Boeing already has in place.

What the model does not calculate, however, is the relative advantages of offshore insourcing or local outsourcing. The model output indicates additional benefits may be recognized through a decrease in transportation/logistics cost, decreased dock-to-dock time, and decreased supplier management cost. Based on potential advantages of both of the other alternatives in achieving these benefits, there may have been a stronger justification for one or both of these alternatives compared to offshore outsourcing.

- I. Technology Clockspeed: (Score: 4 strongly supports offshore outsourcing)**  
*Clockspeed.* The underlying technology for aluminum aero structures is well established, and the rate of innovation is slow. This makes the 737 vertical fin a good candidate for outsourcing.
- II. Product/Process Architecture: (Score: 0 indicates equal advantage)**  
*Modularity.* As in the case of the 777, the 737 vertical fin interfaces with the overall airplane in much the same way. However, due to a lack of modularity in the product design some opportunity for improvement still exists.<sup>88</sup> *Flexibility.* Being more manual and involving more standard tooling, this process is more flexible than the automated CFRP process. *Complexity.* The process complexity of the 737 vertical fin is in some ways less than the 777 because it involves less precise tolerance for the manufacturing environment and does not involve similarly automated technologies.
- III. Supply Base Characteristics: (Score: 3 supports offshore outsourcing)**  
*Capability.* A number of outside suppliers exist with the capability to manufacture aluminum aero structures. *Supplier Power.* There are some potential aspects of supplier hold-up which are mitigated by dual-sourcing. *Downstream relationships.* External suppliers have been very responsive to the needs of their customer, even if located halfway around the world.
- IV. Enterprise Characteristics: (Score: 1 mildly supports offshore outsourcing)**  
*Enterprise Knowledge.* Boeing has a deep base of aluminum manufacturing knowledge. *Competitive Position.* As more suppliers have become capable of performing aluminum aero manufacturing work, Boeing has found it increasingly difficult to remain cost competitive.

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<sup>88</sup> Based on the product design, the 737 vertical fins are not entirely modular. That is, each vertical fin is manufactured in a way that it must be married up with a particular airplane line number. If a 737 vertical fin is damaged in transit, it requires significant additional transaction costs to be incurred for reallocating the ship-sets.

**V. Customer Value: (Score: -1 mildly supports local insourcing)**

*Customer Preference.* Given the more established technology, customers are satisfied with Boeing supplier certification that necessary standards for quality and safety of the product are achieved. *Economic Contribution.* The market price minus the direct material and labor cost for aluminum 737 vertical fins is not as great as if it were lighter composites, or part of a larger capacity airplane structure. Hence, the economic contribution of the aluminum vertical fin is relatively less valuable to the enterprise than the composite 777 fins.

**VI. Exogenous Forces: (Score: 5 strongly supports offshore outsourcing)**

*Foreign Market Access.* At the time when the sourcing decision was made, support for sales of airplanes to China factored significantly into the decision. *Political Forces.* Satisfaction of Boeing IDS military offset commitments was another important benefit recognized by production in Korea.

**VII. Demand Forecast Accuracy: (Score: 5 strongly supports offshore outsourcing)**

The comparatively stable demand signal involves a less dramatic “bullwhip” effect than many other parts and services.

**VIII. Velocity: (Score: -1 mildly supports local insourcing)**

The velocity is negatively impacted by long shipping lead times.

**IX. Quality: (Score: 4 strongly support offshore outsourcing)**

The quality was a more significant challenge within the first 100 shipsets, but the supplier learning curve effect resulted in no negative impact on quality.

**X. Delivery: (Score: 4 strongly supports offshore outsourcing)**

Delivery is in effect 100% satisfied through early shipment of vertical fins to a local supplier warehouse, where the fins are held until required for installation.

**XI. Capacity: (Score: 5 strongly supports offshore outsourcing)**

The cost and time to develop new capacity is an advantage of employing two offshore suppliers with support of their respective governments for developing capacity. Very flexible.

**XII. Production Cost per Unit: (Score: 4 strongly supports offshore outsourcing)**

Lower labor costs make this an advantage for offshore suppliers.

**XIII. Transportation / Logistics Cost: (Score: -3 supports local insourcing)**

Significantly added cost of transportation and logistics. While mainly recurring costs, may also involve non-recurring infrastructure development costs.

**XIV. Investment Cost: (Score: -4 strongly supports local insourcing)**

Supplier selection and negotiation were quite extensive. Significant costs related to transition support team involved with getting new suppliers capability up to requisite levels.

**XV. Supplier Management Cost: (Score: -1 mildly supports local insourcing)**

Significant costs incurred to sustain Boeing support personnel working abroad. Renegotiation has been an issue when changes are requested.

**XVI. Tax Impact: (Score: 3 supports offshore outsourcing)**

Although tariffs are higher with offshore alternative, they are more than compensated for by foreign government incentives.

**XVII.  $\Delta$ Lifecycle Cost: (Score: 0 indicates equal advantage) Unknown.**

**XVIII. Supply Risk: (Score: 1 mildly supports offshore outsourcing)**

Higher risk of poor quality, rework, and scrap within first 100 ship-sets; opportunistic renegotiation (or "assertion"), knowledge dependence, supplier upstream vertical integration, supplier labor disputes, deliberate

underperformance (or “shirking”), capacity dependence, inadequate capability or misrepresentation, supplier inflexibility, inventory holding, logistics and transportation, supplier bankruptcy, etc.

**XXII. Enterprise System Risk: (Score: -1 mildly supports local insourcing)**

Greater relative risk associated with intellectual property breaches (or “poaching”), Information Technology systems breakdown, etc. with offshore suppliers.

**XXIII. Demand Risk: (Score: 0 indicates equal advantage) Not applicable.**

**XXIV. Uncontrollable Risk: (Score: -2 mildly supports local insourcing)**

Greater risk of increased oil prices causing transportation costs to increase over time for offshore alternatives; also, potentially greater risk of political instability and exchange rate inflation.

## 5.6. Additional Considerations: Lessons from the 787 Dreamliner

*...in the real world of irreversible actions and high stakes the need to maintain performance often overrides the need to learn by suppressing new strategies for fear they would cause present harm even though they might yield great insight and prevent future harm (Sterman, 2000, p. 33).*

*Purchasing* magazine named Steven Schaffer its Supply Chain Manager of the Year in 2007, “For his keen insight into supplier-relationship management, his achievements on the 787 program so far, and for his success in revamping the whole supplier-relationship process at Boeing” (Avery, 2007). Since then, a number of challenges have arisen from the 787 global sourcing strategy, due to various unplanned disruptions within the system. Boeing now has an opportunity to learn valuable lessons from their ongoing experience, and help ensure more informed decisions for the future.

In January 2006, less than nine months prior to the first announcement of delays of the 787 program, Schaffer and his team had reported they were more than satisfied with performance of BCA’s suppliers. “Our performance shows that deliveries and revenues are increasing... And, we continue to increase our margins, which is a sign of productivity throughout the whole value chain,” said Schaffer (Avery, 2006).<sup>89</sup> Over time, however, the problems associated with the supply chain strategy have become undeniable.

In August 2007, I was fortunate to have the opportunity to spend a few days with general managers, manufacturing engineers, industrial engineers, and others on the 787 factory floor. What struck me most was a large amount of ‘traveled work.’<sup>90</sup> If in theory a *perfectly lean* enterprise would rely on strictly “pull” processing and perfect first-time quality (which is, by definition, no traveled work), reality proved inconsistent with that ideal. One explanation might be that a schedule-driven demand for large amounts of traveled work had introduced a new layer of complexity and wasteful activity into the production system. As this traveled work began to pile up, it served to exacerbate the

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<sup>89</sup> Note: Higher margins do not necessarily equal higher total profit, nor long-term health for the business.

<sup>90</sup> Boeing uses the term ‘traveled work’ to describe incomplete activities designed to be performed by an upstream actor passed on downstream customer, where they will require additional work for completion.

challenges associated with an already ambitious flow time and production ramp-up schedule.

Example: A particular supplier process may require attachment of many brackets onto a particular subassembly. With over one thousand bracket needing to be installed, a supplier may for any number of reasons (such as adherence to a production schedule) stop short of task completion and leave hundreds of brackets still unattached. The supplier then “travels” the incomplete subassembly and remaining brackets on to final assembly—not across the factory, but across the ocean.

Since the electronic work statement does not indicate the percentage of brackets already installed—but does indicate the number of brackets shipped—it appears to the final assembly personnel that the supplier provided insufficient brackets (missing the number already installed).

Therefore, the work package will sit idle and will not be released to a final assembly mechanic for completion because the information technology system does is not designed to show that the missing XXX brackets are actually *already attached*.

In an April 9, 2008 news release, Boeing stated that the 787 “first flight is being rescheduled due to slower than expected completion of work that traveled from supplier facilities into Boeing’s final assembly line, unanticipated rework, and the addition of margin into the testing schedule” (Boeing, 2008).

The 787 Dreamliner production system was designed for a 3-day final assembly process flow. While seemingly “lean” with respect to assembly flow time, other value chain partners were expected to complete some of the value-added work previously designed to be accomplished during final assembly.

In the early summer of 2007, Boeing learned that there was a shortage of aerospace-grade fasteners for the new 787 Dreamliner and that a significant amount of unfinished work was being passed on by suppliers. Boeing has since delayed the 787

delivery schedule three times, making it about eighteen months behind schedule. Furthermore, BCA has implemented measures to improve the supply chain, such as recently acquiring Vought Aircraft Industries' stake in Global Aeronautica LLC, a 787 fuselage sub-assembly facility in South Carolina.

After being reassigned, Boeing's former 787 program leader, Mike Bair, suggested that in the future the company wouldn't rely on such a far-flung supply chain in building its next jet (Dunlop, 2008). With partners located in Kansas and South Carolina, Japan and Italy, Boeing has required a fleet of modified 747 freighters just to ferry assemblies back and forth. Bair also noted Boeing likely wouldn't use some of its 787 suppliers again, but declined to name which ones.

In Chapter 5, we examined the "current state" analysis of BCA's strategic sourcing decision process, along with a proposed decision-support model designed to help the company make more consistent, clearly documented, and ever-more informed strategic sourcing decisions. Finally, Chapter 6 will offer an overall summary, a list of findings and recommendations, and recommended areas for further study.

## 6.0 SUMMARY, FINDINGS & RECOMMENDATIONS

Improving the strategic sourcing process within a firm requires us to first *understand the structure* of the system that drives sourcing decisions *and the effects* of specific actions on system performance. Boeing's global sourcing system is extremely complex—it is continuously evolving, and some sourcing actions yield irreversible consequences. Furthermore, long time delays between most BCA strategic sourcing actions and their effects on the state of the system result in historical decision contexts very different from the current situation through which we view their effects. As such, it is extremely difficult for the organization to accumulate experience, test hypotheses, and improve.

The model presented in this work is intended as a holistic approach toward strategic sourcing decision-making, seeking to incorporate the effects of strategic sourcing actions on all actors within the value chain, as well as stakeholders within the extended enterprise. By attempting to identify the system elements, relationships, goal, inputs, controls, and outputs, we model the system in order to help us gain insight into the most significant cause and effect relationships driving the behavior of the system. Twenty-one factor inputs across the Strategic, Operational, Financial, and Risk dimensions comprise the relevant characteristics used to evaluate specific sourcing alternatives. An aggregate function across these four dimensions helps us to compare two sourcing alternatives, using a metric of 'overall value to the extended enterprise.'

By applying the model to two case examples—the 737 vertical fin and the 777 vertical fin—we test the proposed model's validity and usability and find it to be satisfactory for the expressed purposes of improved standardization, explicit communication/documentation, and flexible/scalable structure. However, a significant limitation remains inherent in the proposed model due to its methodology of subjective weighting and scoring assessments. Such qualitative assessments are vulnerable to individual or collective bias. Nonetheless, this model should be viewed as a start point, and a basis for further improvement.

Based on interviews and observations of strategic sourcing meetings from June-December 2007 with Boeing Commercial Airplanes, a very well-designed high-level gated process structure is in place at the company.

***Finding: Cross-functional strategic sourcing decision teams***

***Recommendation:*** Sustain the current high-level organizational framework and expand to include external and internal customers, as well as other potentially valuable contributors to the strategic sourcing dialog.

***Finding: Emphasis on “enterprise partner” long-term sourcing vision***

***Recommendation:*** Sustain to further strengthen relationships and build trust. In light of the challenges related to the 787, be aware of potential tendencies for the company to regress toward a more adversarial mode of interacting with suppliers.

***Finding: Strong motivation to improve strategic sourcing practices***

***Recommendation:*** Sustain and recognize current challenges as opportunities to learn and improve strategic sourcing processes. There are outstanding people working very hard to help the company advance its strategic sourcing process.

***6.1. Opportunities for Improvement***

In the past, the view of strategic sourcing within pockets of the BCA organization appears to have been constrained by the notion that sourcing strategy should be about *minimizing cost* for some minimum required service level. By changing the organizational perspective to recognize global sourcing as an opportunity to *create and deliver maximum value* for the customer, this new approach can enable Boeing to effectively address the challenges it will face in the future. Leaders at all levels should recognize strategic sourcing as an opportunity to reinforce Boeing’s competitive position as it copes with the threat of new entrants and strong forces of vertical disintegration inherent to a mature industry.

The supply chain must evolve along with the market, as products in different stages of their lifecycle have different needs. As the industry clockspeed accelerates, the ability to quickly adapt the supply chain becomes more valuable. Boeing can achieve its vision of a supply chain which harnesses the forces of globalization and new market possibilities to add to the enterprise competitive advantage.

At the tactical level, a number of opportunities exist for BCA to improve. In particular, alignment of individual sourcing decisions with the overarching strategy and development of a more standardized, unambiguous approach toward factor analysis and integration will help improve organizational learning, and consequently the quality of strategic sourcing decisions.

***Finding: Non-standard analysis at the detail level.*** Complex sourcing analysis processes, multi-discipline involvement, and a changing workforce makes consistent application of standard processes a significant challenge. Since historical documentation presents explicit analysis of only *some* of the important factors relevant to sourcing decisions, it is unclear whether undocumented factors were considered, and if so how they were assessed and integrated into the decision process.

***Recommendation:*** Facilitate more process standardization through training and organizational discipline. Through a more consistent approach and a standardized feedback process, an opportunity exists for BCA to continuously improve the quality of its strategic sourcing decisions.

***Finding: Emphasis on short-term financial metrics,*** such as: traditional accounting-based cost reduction, fixed asset reduction, and sales emphasis to increase revenue

***Recommendation:*** Emphasize long-term “enterprise maximum value” metrics, which explicitly incorporate strategic and operational value assessments with financial value.

***Finding: “Ad hoc” risk analyses***

***Recommendation:*** Conduct deliberate risk modeling for strategic sourcing with due diligence, consultation with customers, and defined knowledge management strategy in accordance with evolving core competencies.

***Finding:*** Non-value added accounting complexity in the form of a 15-pg accounting NPV analysis spreadsheet (including overhead allocation) to support decision-making

***Recommendation:*** Substitute managerial accounting metrics which consider only unique costs and “contribution” of a product to the joint costs of the enterprise.

***Finding:*** Reactive offset-related work placement decisions “after the fact”

***Recommendation:*** Analyze (by product) all BCA current state sourcing methods and how each aligns with the future state business strategy; evaluate future possibilities for “proactive” work placement.

***Finding:*** Organizational resistance, sensitivity, and lack of transparency; may be in part due to different strategic perspectives and time horizons, and ongoing 787 sourcing challenges (Global Partners), as well as emotional attachment to complex cost estimation tools and traditional accounting techniques (Finance)

***Recommendation:*** Leadership support, including one high-level process leader responsible for enterprise-wide alignment and management; empower multiple leaders at different levels and across silos to share information and develop effective strategies and tactics for sourcing.

***Finding:*** Lack of systematic feedback process for strategic sourcing; sourcing practitioners are focused on near-term deliverables such that specific time for systematic reflection and process improvement is lacking

***Recommendation:*** Implement continuous improvement feedback through annual review examining the effects of past 1 to 10-year strategic sourcing actions.

## ***6.2. Areas for Further Study***

While completing this work, I came to appreciate the difficulty and complexity of the task at hand. In this thesis I have emphasized a holistic approach to strategic sourcing analysis and unambiguous communication and documentation of the reasons why strategic sourcing decisions are made in order to allow the organization to learn. From

this point, improved factor integration and refinement of the decision support tool, as well as possible development of a systems dynamics model, are recommended areas to focus efforts for deeper insight into the benefits, costs, and risks of global sourcing alternatives.

*Refinement of the decision-support tool.* Weighted average approaches like the one presented in this thesis come with significant limitations. As described by Doug Hubbard, a decision analysis consultant and author, such approaches are unlikely to improve decisions for a number of reasons, such as (Gilmore, 2004):

- the fundamental concept is flawed if the weightings aren't factually based;<sup>91</sup>
- conflicts of interest may arise when people completing the scoring have biases and vested interests in the outcome;
- people frequently override the answer the method gives to get the answer they want;
- people really don't trust the answers they get; and
- it often doesn't include real decision criteria<sup>92</sup>.

Recognizing these limitations, the intent of this work has been to view the model as an iterative step improvement from the current process upon which to base further improvement efforts.

*Systems Dynamics Modeling.* System-level simulation can be a valuable tool for representing and measuring time-based performance of a real-world stochastic production and business system. In a systems dynamics model, a few vital inputs should be chosen from the entire system of controllable and noise variables<sup>93</sup>, and the focus of improvement should be on controlling these inputs. Although not a "crystal ball" through

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<sup>91</sup> Ratings (say a scale of 1-5 for each category) often don't really reflect the true differences in sourcing alternatives. Is a vendor that receives a 4 really twice as good in that category as one which gets a 2?

<sup>92</sup> Decision-makers often choose vendors because they just feel more comfortable with them or their team. But you never see this as one of the categories in a weighted average, along with many others. Risk, a very important factor, is often not included explicitly.

<sup>93</sup> Note: Noise factors are factors that cannot be controlled or can be controlled at an unaffordable cost, such as randomness and variability factors.

which to predict and optimize system behavior, as a tool and an experimental platform such models can lead to valuable system information that benefits planning, design, and optimization, particularly when combined with appropriate statistical analyses, experimental design, and efficient search engine.

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## APPENDIX A: INTERVIEW QUESTIONNAIRE

### **General Perceptions of Strategic Sourcing**

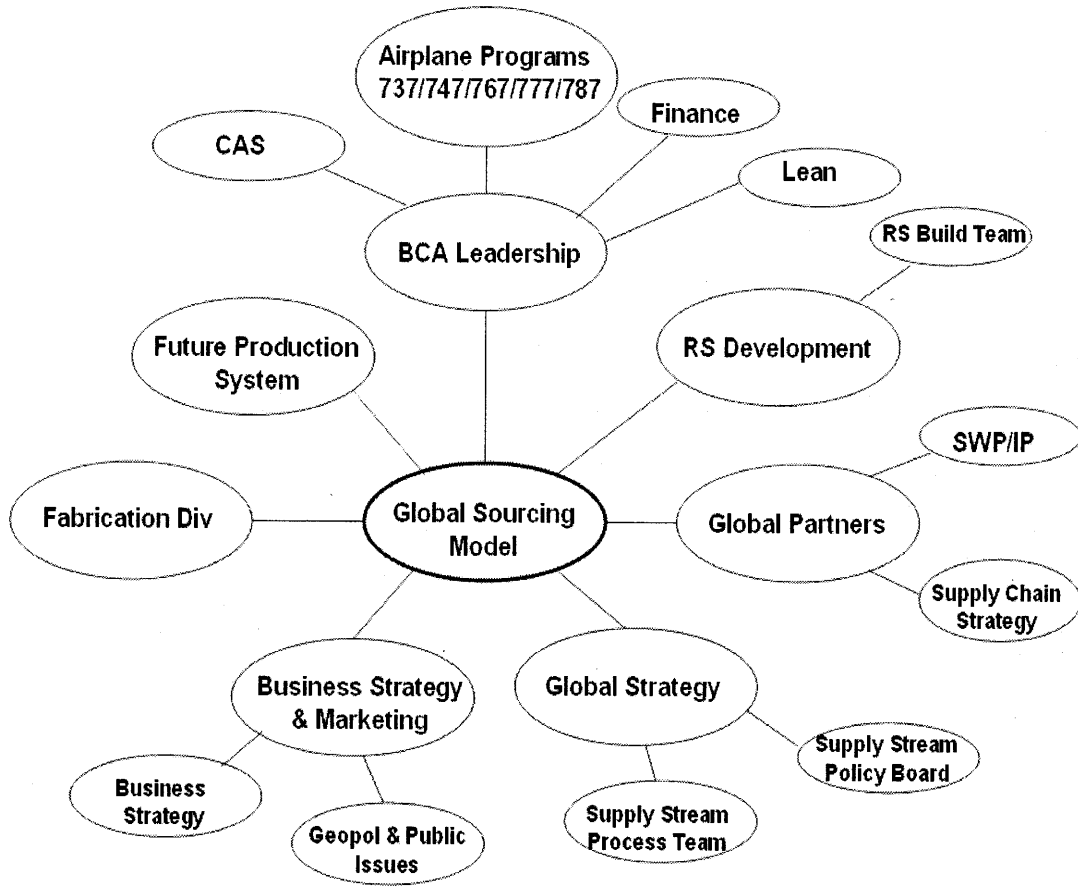
1. What are your general perceptions of company sourcing practices? (related to insourcing, outsourcing, and offshoring)
2. What elements are important to consider when thinking about supply chain costs and risks?
3. What does BCA's existing supply chain look like? (i.e. What is sourced where?)

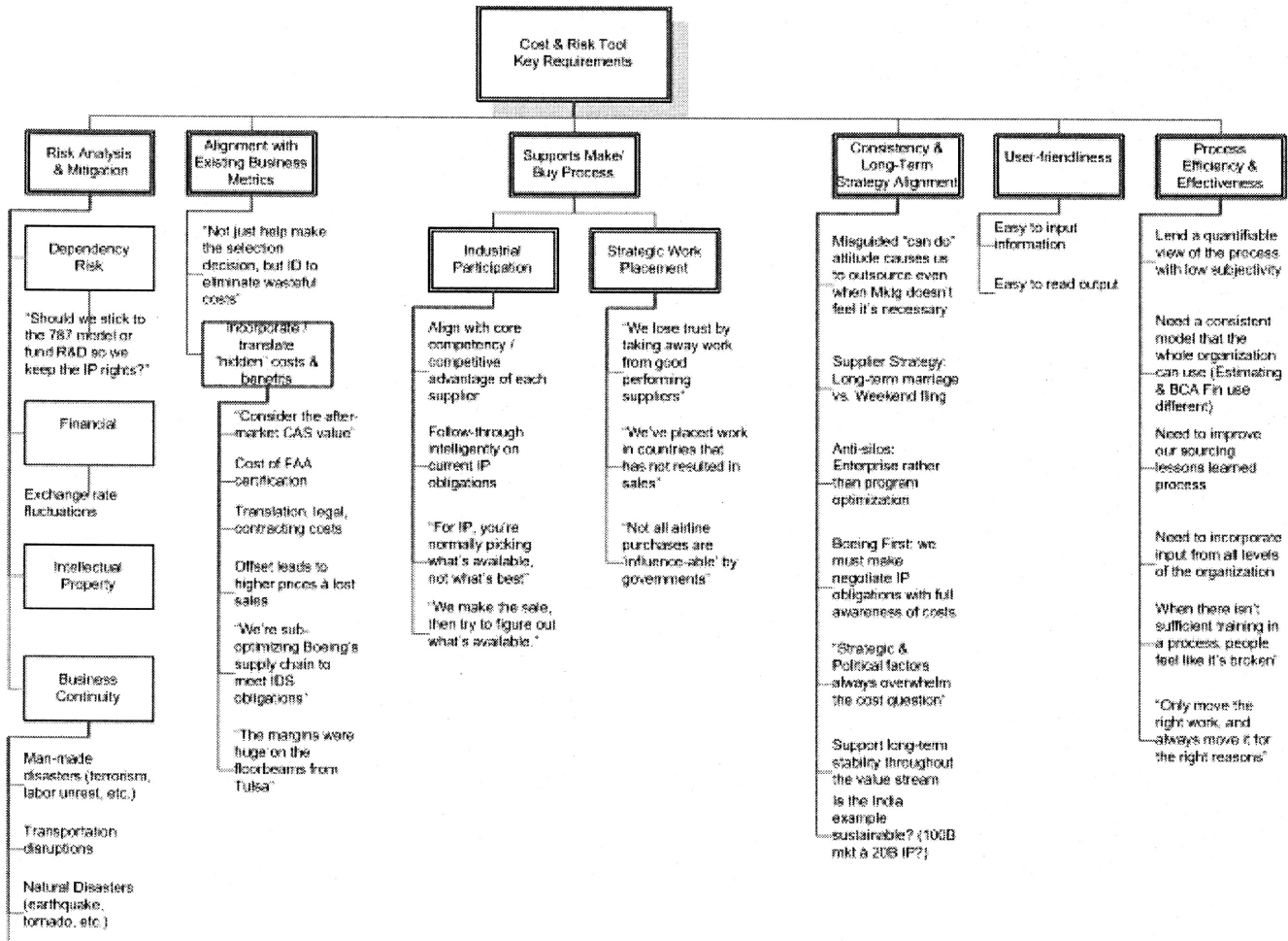
### **Work Transfer Decision-making**

4. Please describe Boeing's standard process for work transfer decision-making.
5. What metrics are appropriate to understand the benefits, costs and risks of potential work transfers?
6. What costs have been overestimated or underestimated in the past? Why?
7. Has Boeing had any disappointments or shocks related to suppliers? Why?
8. How does Boeing estimate opportunity costs for strategic sourcing?
9. How available and to what level of accuracy confidence is Boeing's / supplier cost data?
10. Does Boeing currently use software packages to estimate total costs and/or risks associated with outsourcing?
11. What is Boeing's standard future cost savings threshold to justify changing suppliers? (e.g. simple percentage—must save > 40% to cover all hidden costs)

### **Integrated Cost Model**

12. How would you envision a total, integrated supply chain cost / risk model?
13. What types of inputs and outputs should the model have?
14. Who, when, and how do you think such a model would be used for decision-making?
15. In creating a framework / model, what user should it be designed for? (Quick high-level analysis or detailed in-depth analysis?)





## APPENDIX D: DETAILED COST LIST

- I. *Price / Production Cost per Unit.* Sum of all direct material and labor costs divided by the number of units.
  - Material cost
  - Direct hourly labor rate
    - Wage growth rate
    - Labor productivity
    - Learning curve
    - Cost of Management
    - Transportation & Logistics
    - Cost of Procurement / Overhead
  
- II. *Transportation / Logistics Cost.*
  - Dealing with inferior infrastructure
  - Transportation
  - Receiving (including moving heavier packaging for shipment protection)
  - Inspection
  - Holding inventory (heating costs, warehouse maintenance, etc.)
  - Insurance
  - Capital charge for keeping inventory
  
- III. *Investment Cost (Capability / Capacity Development).*
  - Supplier Selection & Negotiation
    - Search for and visit supplier
    - Negotiation with supplier
  - Transition Support Team (GP, Eng, Tooling, Manuf)
    - Gather information and codify knowledge of the process transferred
    - Package the process for IP protection
    - Modify and pilot the process outsourced and re-sourced (incl modification due to different climate)
    - Supplier initial training and technical support
    - Qualify new supplier
    - Qualify new sub-tier supplier
    - Procurement Quality Assurance audit
    - Per diem (Including travel and lodging)
    - other GP assistance
    - other Engineering assistance
    - other Tooling assistance
    - other Manufacturing assistance
  - Tooling Cost
    - Tool design / redesign
    - New equipment
    - New tools (incl. rate tooling)
    - Initial rework

- Breakdown
  - Setup
- Manufacturing Cost
  - Engineering design / redesign
  - New equipment
  - Build ahead premium
  - NC programming
  - Planning and inventory management
- Facilities / PP&E impact
  - Buy or sale raw land (Property)
  - Buy or sale building (Plant)
  - Buy or sale equipment (Plant)
  - Clear building
  - Prepare building for sale or lease
  - Demolish or modify building
  - Site clean-up (Including environmental)
  - Lease costs or early exit penalties
  - Permits, commissions and other fees
  - Transportation (Freight and Internal)
  - Move equipment, tools or computers
  - Build new cribs/kits (Boxes)
- Labor
  - Local personnel recruit and training
  - Restructure redundant capacity and labor
  - People disruption
  - Skill retention premiums
- IT / Computing Cost
  - Systems conversion
  - Buy computing equipment
  - Install network
  - Boeing owned applications to suppliers
  - Setup data transmission security
  - Add or Delete products or services (Including sub-contracting)
  - Add supplier to internal IT system
  - Invest in suppliers' IT systems (e.g. MRP, ERP, TCM, etc.)

#### *IV. Supplier Management Cost.*

- Impact of residual supply from previous supplier
- Sustaining support pax working abroad
- Quality Assurance audits
- Local hires
- Supplier training and technical support
- Co-operation with supplier for innovation
- Update forecast and convey it to suppliers
- Performance review and meeting
- Renegotiation
- Costs of phone calls, faxes, video conferences

*V. Tax Impact.*

- Tax and duty
- Tax credits
- Job training subsidy
- Other state/federal aid (cost mitigation)
- Discount term
- Benefit from payment terms changes

*VI.  $\Delta$ Lifecycle Cost.*

## APPENDIX E: INTEGRATED RISK FRAMEWORK

		Supply Base Risk Factors	Boeing Enterprise Risk Factors	Customer Base Risk Factors
<b>Controllable</b>	<b>Strategic</b>	<ul style="list-style-type: none"> <li>▪ Diversification</li> <li>▪ Relationship-specific Investment</li> </ul>	<ul style="list-style-type: none"> <li>▪ Labor Dispute (Climate)</li> <li>▪ Intellectual Property Breaches / Poaching</li> <li>▪ Knowledge Dependence</li> <li>▪ Supplier Upstream Vertical Integration</li> <li>▪ Deliberate Underperformance / Shirking</li> <li>▪ Opportunistic Renegotiation / Assertion</li> <li>▪ Moral Hazard</li> </ul>	<ul style="list-style-type: none"> <li>▪ OEM Supplier Power</li> <li>▪ Environmental sustainability</li> </ul>
	<b>Operational</b>	<ul style="list-style-type: none"> <li>▪ Poor RM quality</li> <li>▪ Excessive handling at border crossings</li> <li>▪ Single-source dependency</li> <li>▪ "Bullwhip" effect</li> </ul>	<ul style="list-style-type: none"> <li>▪ IT Systems Breakdown</li> <li>▪ Capacity dependence (high utilization rate)</li> <li>▪ Poor supplier quality / misrep.</li> <li>▪ Inadequate supplier capability / misrep.</li> <li>▪ Supplier inflexibility</li> <li>▪ Single-source dependency</li> <li>▪ "Bullwhip" effect</li> </ul>	<ul style="list-style-type: none"> <li>▪ Safety</li> <li>▪ Delivery lead time</li> <li>▪ Inaccurate Demand Forecast</li> <li>▪ Obsolescence</li> </ul>
	<b>Financial</b>	<ul style="list-style-type: none"> <li>▪ Winner's Curse / Bid too high</li> </ul>	<ul style="list-style-type: none"> <li>▪ Inventory Holding Costs</li> <li>▪ Logistics &amp; Transportation Costs</li> <li>▪ Labor rate inflation</li> <li>▪ Long term operating costs</li> <li>▪ Rework / scrap costs</li> <li>▪ Supplier Bankruptcy</li> <li>▪ # &amp; Financial Strength of Customers</li> </ul>	<ul style="list-style-type: none"> <li>▪ Fixed costs</li> <li>▪ Operating costs</li> </ul>
<b>Uncontrollable</b>	<ul style="list-style-type: none"> <li>▪ Natural Disasters (Geographic Concentration)                             <ul style="list-style-type: none"> <li>▪ Acts of War</li> <li>▪ Terrorism</li> </ul> </li> <li>▪ Legislation / Regulation</li> <li>▪ Financial Recession</li> <li>▪ Transportation Capacity</li> <li>▪ Transportation Pricing                             <ul style="list-style-type: none"> <li>▪ RM Availability</li> <li>▪ RM Pricing</li> </ul> </li> <li>▪ Exchange rate fluctuation</li> <li>▪ Industry-wide capacity</li> </ul>			

## APPENDIX F: GLOSSARY

**Effectiveness:** a measure of a system's ability to meet the objectives of its stakeholders

**Efficiency:** a measure of a system's ability to achieve its objectives with the least amount of waste or non-value-added effort

**Global sourcing:** strategic sourcing in a global setting often aimed to exploit global efficiencies in the delivery of a product or service

**Globalization:** the growing economic interdependence of countries world-wide through the increasing volume and variety of crossborder transactions in goods and services and of international capital flows, and also through the more rapid and widespread diffusion of technology (International Monetary Fund, 1997); international integration driven by a combination of economic, technological, socio-cultural and political forces

**Horizontal integration:** style of managerial control in which a firm consolidates holdings across multiple industries

**Insourcing:** delegation of operations or jobs from production within a business to an internal entity that specializes in that operation; opposite of outsourcing

**Offshoring:** transfer of an organizational function to another country, regardless of whether the work is outsourced or stays within the same corporation

**Outsourcing:** transfer of the management and/or day-to-day execution of an entire business function to an external service provider, regulated by contractual agreement

**Strategic sourcing:** an institutional procurement process that continuously improves and re-evaluates the purchasing activities of a company; one component of supply chain management

**Supply chain:** system of organizations, people, technology, activities, information and resources involved in transforming natural resources, raw materials and components into a finished product delivered to the end customer; supply chains link value chains

**Supply chain management (SCM):** the process of planning, implementing, and controlling the operations of the supply chain as efficiently as possible; spans all movement and storage of raw materials, work-in-process inventory, and finished goods from point-of-origin to point-of-consumption

**Value chain:** chain of ordered activities which products pass through and gain some value as a direct result of each activity

**Vertical disintegration:** breakdown of a production process into separate companies, each performing a limited subset of activities required to create a finished product, typically to share risk in volatile markets or resulting from various diseconomies of scale or scope

**Vertical integration:** style of managerial control in which a firm owns its upstream suppliers and its downstream buyers

**Value stream:** all activities, both value added and non-value added, required to bring a product from raw material state into the hands of the customer, bring a customer requirement from order to delivery, and bring a design from concept to launch