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Understanding Managerial Decisions about Global Sourcing: Offshoring and Reshoring of Production

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UNDERSTANDING MANAGERIAL DECISIONS ABOUT GLOBAL SOURCING: OFFSHORING AND RESHORING OF PRODUCTION

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UNDERSTANDING MANAGERIAL DECISIONS ABOUT GLOBAL SOURCING:

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As international commerce continues to emerge due to telecommunication and transportation breakthroughs, the eagerness of companies to send particular business functions offshore increases. Offshoring is the removal of a company function (particularly, manufacturing) from a domestic location to a remote destination. Since many developing economies contain low labor wages, companies in the United States and Europe are able to leverage cost savings by paying low compensation to foreign production employees. The low cost concept, though, does not always offer significant financial reward. For companies with particular product types, business models, or limited experience, offshoring proves to be an expensive mistake that is difficult to reverse. Even so, some U.S. enterprises are reshoring their production function to combat the issues faced in the foreign manufacturing sector. This study aims to investigate the problems of offshoring and proposes a "systems-view" decision framework for global sourcing.

DEDICATION

I dedicate this research to God, my loving family, and my supportive friends.

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Dr. Greenwood and the Department of Industrial and Systems Engineering deserve special thanks for providing me the means to complete this study. In addition, I offer sincere gratitude to the Reshoring Initiative and its founder, Harry Moser, for offering not only useful research materials but also valued collaboration.

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CHAPTER I

INTRODUCTION

1.1 Background

As globalization continues to grow in popularity, businesses of all sizes and markets look to capitalize on new international opportunities. Potential suppliers, customers, and competitors are no longer found in a few locations. For some companies, emerging technology and transportation advances enable entrance to new markets with better or cheaper products than the established competition; however, many companies suffer from the invasion of foreign competition. These struggling enterprises, generally located in developed countries, look to save costs in order to match their competitor's prices.

Offshoring[1] enters the discussion in the executive suite soon after the preceding situations transpire. For several years, large companies headquartered in the United States have used cheap foreign labor to complete functions like manufacturing at lower cost than possible in America. As long as the savings gleaned from using foreign workers offsets transportation and logistics costs, an offshored production department offers a way to enable a low cost competitive strategy.

Unfortunately for many companies, offshoring simply is not "as easy as advertised." Organizations facing global sourcing decisions have to balance choices of

[1] *Offshoring* is an organization's use of an intercontinental region's labor resources to serve customers in a domestic setting. Generally, offshoring leverages low cost labor resources in order to develop a cost advantage over domestic counterparts. Offshoring is a type of manufacturing sourcing strategy.

offshoring, outsourcing[2], and insourcing[3] among several key functions. Since the many roles in providing a product or service to a customer are highly related to one another, moving a vital function like manufacturing to a completely different geography has major repercussions along the entire supply chain. In particular, inexperienced enterprises are vulnerable to ballooning inventory costs, cultural juxtaposition, unpredictable delivery times, and intellectual property infringement.

This study aims to outline a standard practice for offshoring production. In order to understand the many complexities associated with this strategy, literature provided by leading supply chain professionals is analyzed in conjunction with enterprise systems engineering[4] concepts. Viewing offshoring as a decision in a large, complex system enables a holistic[5] perspective, which provides a logical means for finding best practices for global sourcing of production. Moreover, a standard decision methodology offers insight into the recent trend of reshoring[6]. In hopes of providing further interest into the research of this topic, this study emphasizes awareness about several complex facets of the offshoring problem, including the complexity of an international firm's cash flow structure, the need for a systems view toward strategy selection, defining global risks in

[2] *Outsourcing* is an organization's use of a separate company to complete a task necessary to serving a customer. Outsourcing is a typical choice for companies that lack expertise or capital assets for a particular function.
[3] *Insourcing* is an organization's choice to own and to operate a functional role necessary to serving a customer. Insourcing many key functions results in a vertically integrated supply chain.
[4] Enterprise Systems Engineering is the cross-disciplined study of organizations as systems; its application toward a company focuses on strategic organizational design for emerging markets and their resultant challenges [1].
[5] *Holism* is "the idea that a system exhibits properties and behavior that cannot be attributed to any one of its parts" [2].
[6] *Reshoring* is the replacement of an *offshoring* strategy with domestic production operations. Reshoring actions may consist of partially removing foreign operations from the organization. In addition, a company's choice to discontinue expansion with offshored labor but still maintain its current foreign operations is considered a reshoring strategy.

the supply chain, and constructing a model architecture for valuating different strategic choices.

1.2 Problem Statement

A firm that cannot make a successful decision about a global sourcing strategy normally has inexperience in international manufacturing. For companies that do not have experiential knowledge, the selection of a strategy may entail simply choosing the cheapest option; however, a choice among several complex supply chain design options should not be based on cost alone. The minimization of production costs does not need to supersede the overall goals of the firm. Cash inflows and outflows need to be adjusted for risks[7] that are inherent to the global environment. In addition, the common methods for incorporating risks into financial analysis are inappropriate for dealing with business arenas as dynamic as international supply chains. Understanding a firm and its supply chain as a complex system is a necessary step toward creating a standard process that most companies can apply in order to evaluate different strategic options.

1.3 Research Objectives

The objectives of this thesis are to

1. Provide a glossary of nomenclature about sourcing methodology based on reviewed literature,
2. Provide a list of current frameworks and cost approaches used for sourcing based on reviewed literature,
3. Introduce a holistic approach for organizing the cost and risks associated with offshored production,

[7] *Risks* are causes of *uncertainty* in values. A significant risk in a value may entail the need to quantify the level of uncertainty in the value.

4. Introduce a new decision method for offshoring and reshoring based on current frameworks and methodologies, and
5. Provide a vision for further research about complex offshoring issues and opportunities for the application of computer-aided engineering.

The Glossary of Terms in Appendix A addresses the requirements of the first objective; in addition to providing specific definitions for all of the terms used in the study, the glossary includes discussion of discrepancies among terms found in the literature. Chapter III addresses both objectives two and three. Meanwhile, Chapter IV describes the decision method for global sourcing mentioned in objective four. Finally, Chapter V includes the vision for future modeling and application to computer-aided engineering software. In addition to all of the preceding objectives, Chapter VI includes concluding remarks and specific areas of further research, while Appendix B contains additional discussion about exchange rates.

1.4 Overview of Research Methodology

The application of systems thinking to the global sourcing decision is a young research area; therefore, the literature review in the proceeding chapter is critical. Since the literature offers several avenues for investigation, each following chapter contains a section to explain the methodology associated with that area of research. This organizational structure logically arranges the research steps taken for each investigated area.

In order to understand adequately the problems at hand, an enterprise systems engineering (ESE) perspective dominates most discussion. Because ESE emphasizes corporate strategy, overall company goals, and emerging environments, this approach is

thought to be acceptable for identifying the critical issues in the problem. Furthermore, the massive opportunity for scope creep in this study is controlled by the reliance on ESE viewpoints that emphasize holistic, upper-level research. This characteristic is intended to accentuate the several areas of global sourcing in need of further research.

The most important characteristic of ESE applied to this study is the field's emphasis on a system's numerous interdependencies among several components [2]. Discovering the nature of different relationships in the firm and the supply chain is crucial to quantifying the offshoring problem. In Chapter III, the current viewpoints, which lack focus on supply chain and company relationships, are identified as a problem needing more scrutiny. Understanding all of the variability associated with offshoring crucially relies on the systems view methodology presented by Giachetti in *Design of Enterprise Systems* [2].

As a paradoxical consequence of the holistic focus offered by ESE, the *tactical* application of any solution presented in this study is specifically noted for issues. Solutions that are too difficult to apply or that remain undeveloped for industry application are undesired. For this reason, future studies are an opportunity for preparing the suggested solutions provided in the thesis for mainstream use.

At the conclusion of Chapter II, an affinity diagram provides a means for organizing the remaining portion of the study. By recognizing important organizational features of the problem, this diagramming technique pinpoints the key components to the global sourcing decision and outlines the scope of the project. From this step, the defined vocabulary, the cash flow structure, the decision process, and the model vision are identified as vital components for answering the problem statement and, as a result, are included in the aforementioned research objectives.

CHAPTER II

LITERATURE REVIEW

2.1 The Offshoring Problem

Offshoring is an attractive option for many companies looking to cut manufacturing costs. Because certain foreign labor markets offer significantly lower labor compensation rates, organizations can leverage offshoring strategies to reap financial benefit. In particular, offshoring the manufacturing function of an enterprise is commonly the best option for savings. For U.S. manufacturers, cost of production declined from 1995 to 2008 in part from the implementation of new strategies, such as process improvement programs and offshoring [3]. While programs such as Lean or Six Sigma literally create improvement in productivity, offshoring increases this metric through the removal of low value-creating activities from the U.S. manufacturing sector. This statement illustrates the difference between offshoring and process (or product) improvement strategies: though both strategies offer savings toward manufacturing costs, only one of them (process improvement) physically amends the production methodology for cost reduction.

Most organizations that offshore production choose countries in the southeast Pacific (e.g., Malaysia, India, the Philippines, and China). Of these countries, China has emerged as the favorite for U.S. manufacturers [3]. The reason behind China's dominance in production stems not only from the high potential for labor compensation savings but also from the favorable exchange rate. Since China operates a command

(rather than free market) economy, the value of the Yuan is determined through decisions from the communist-led People's Bank of China [4]. The Chinese government's dedication to undervaluing its currency (at nearly 50%) coupled with the country's capable and expanding technological expertise makes China the world's largest exporter for manufactured goods [3]. U.S. companies strategically investing in Chinese facilities have fortified this manufacturing prominence. In 2007, offshoring in China offered a median ROIC (return on investment capital) of 50%, a value almost three times greater than the median ROIC in the U.S. [5]. Although the reasons to offshore are quite evident, particular issues with locating production in foreign countries like China are emerging.

In recent years and through the economic downturn of the late 2000s, several companies have experienced unexpected and highly negative results from offshoring. The reasons for companies experiencing poor performance with offshored investments stem from many unplanned costs, risks, and key misconceptions associated with remote facilities. Unfortunately for many enterprises, the decision to offshore a company function results purely from the desire to gain compensation savings. Often times, companies seek to optimize labor rates without studying the side effect of the strategy. Harry Moser, founder of the Reshoring Initiative, says, "We have pretty good anecdotal evidence that purchasing agents and supply chain managers just compare f.o.b. [freight on board] prices, and if they're 20 to 30 percent lower, they buy from China" [3]. A major fault with only acknowledging performance metrics such as f.o.b. forecasts is their inability to quantify the external factors associated with foreign locations. Generally, common characteristics[8] of the manufacturing sector differ between China and the U.S. Whether poor decision procedures derive from an unhealthy eagerness to minimize cost

[8] Section 2.3 addresses manufacturing sector comparisons between China and the U.S.

or a conceptual misunderstanding of global supply chains, several organizations display the need for standard practices in ranking the value of domestic and nondomestic production options.

Further complication to the matter occurs when considering cost savings options from a broader perspective – in other words, is offshoring the only option? The decision to offshore production commonly overlooks two basic assumptions about policies on reducing costs: product redesign often offers the greatest potential for savings, and offshoring will include not only labor rate savings but also several related costs [4]. With many business leaders seeking to correct their organizations' offshoring problems, reshoring is a popular choice for several U.S. enterprises. These ideas not only raise concern about shortsighted decision techniques for offshoring but also introduce the need to include other saving opportunities in a holistic approach.

2.2 The Reshoring Trend

Michael Collins, president of MPC manufacturing, categorizes the issues with offshoring in the following list:

1. Ensuring delivery times and dealing with customer change orders,
2. Maintaining quality standards and coping with damaged shipments,
3. Accepting rising foreign costs and increasingly unfavorably financial terms,
4. Managing large inventories and shipping costs, and
5. Preventing counterfeiting [6].

Within this list, Collins encompasses most issues experienced by supply chain managers that have fallen subject to negative offshoring trends. Although the understanding of these issues is vital to solving this problem, most companies can only combat these

negative side-effects through a complete reversal of strategy. Thus, reshoring is a popular option for organizations suffering from problems in the preceding list. Michael Collins says the budding reshoring trend has several drivers, including changes in cost forecasts since 2001, reduced quality standards, volatile demand, and a lack of control over global lead times [7].

In dealing with offshoring, some supply chain managers have begun to understand a critical relationship: the distance between manufacturing facilities and end-users is directly proportional to the "friction, fragility, and variability" of supply chain costs [8]. The complexity introduced from the physical and cultural distance associated with offshoring provides a legitimate concern. As businesses begin to mature from providing transaction-based services to managing long-term supplier and customer relationships, the many reasons to reshore resound emphatically in many industries. Some experts predict that organizations will continue to pay more attention to every cost associated with order fulfillment and take measures to ensure sustained customer relationships through shortening lead times [9]. Some methods of long-term supply chain cost reduction may include reshoring strategies.

The balance between companies' offshoring and reshoring business functions[9] depends on a broad understanding of all costs associated with either decision. Other factors, such as tax rates or political policy, also warrant scrutiny. For example, the U.S. corporate tax level and its tax policy currently offers incentive for companies to offshore manufacturing if profit margin is made outside of domestic borders [3]. This incentive, though, only extends to the tax perspective – other areas of cost concern, such as excess

[9] *Business Functions* represent different areas of competence within a company; these include human resources, manufacturing, and information technology.

inventory or quality reduction, must be considered as well. Therefore, the many offshoring costs outlined by experts must outweigh the higher compensation and tax rates of the U.S. before reshoring can become a viable option.

2.3 Global Sourcing Defined

As enterprises begin to compete on prices of manufactured goods, particularly in commodity-style categories, companies often offshore particular business functions. This method of offshoring, consisting of moving low-value creating activities to locations of cheap labor, can be referred to as low-cost country sourcing[10] (LCCS) [10]. Offshoring, then, can be understood as a broader issue of global sourcing. In order to best quantify the problems surrounding decision-making for offshoring, the sourcing process should be sufficiently understood.

Sourcing[11] is defined as "the entire set of business processes required to purchase goods and services" [11]. These processes include procurement, a common but incomplete synonym of sourcing. The options of sourcing decisions most commonly include insourcing, outsourcing, and offshoring. Meanwhile, procurement is literally the steps taken to purchase goods and services from a group of predefined suppliers. (Procurement implies transactional and planning activities while sourcing implies long-term strategy.) While the concern of procurement is to schedule and to achieve the delivery of purchases at the lowest cost, sourcing takes a much broader role in supply chain management [11]. Sourcing is best understood by separating it into five

[10] *Low-Cost Country Sourcing* (LCCS) is "companies… shifting their repetitive and lower-value work to more economical locations in an attempt to compete on lower prices" [10].
[11] *Sourcing* is "the entire set of business processes required to purchase goods and services" [11]. In the case of global sourcing for production, labor markets represent "purchased" goods and services.

consecutive sub processes; to deliver a product to customers, these five steps (illustrated in Figure 2.1) should be taken by any responsible organization [11].

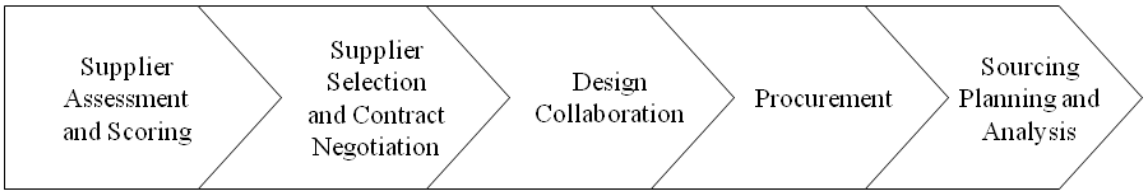

Figure 2.1 The Sourcing Process [11]

Many observers may not consider the steps outlined in the figure surprising or groundbreaking; however, some companies are bypassing several of these steps when haphazardly offshoring their production. Particularly, design collaboration and sourcing analysis are neglected. The ever-present mention of inexperienced companies' overlooking strategy and focusing on price is highlighted by Figure 2.1. Some experts may argue that the sourcing methodology presented is exclusively related to outsourcing, not offshoring. Since offshoring, even when executed through vertically integrated operations[12], relates to choosing location, separates business functions, and strives to reach efficient operational status, a case can be effectively made that all offshoring decisions should follow a sourcing model. The broader issue of offshoring and LCCS relates to *global* sourcing. In order to enact strong direction toward a vision, companies should understand completely the role that sourcing plays in their competitive strategy.

[12] "Vertically integrated offshoring" refers to an organization owning its offshored function or process in an environment foreign to domestic operations. Often, large companies that manufacture commodity products display this quality – insourced, offshored production. For smaller companies, operations are traditionally outsourced and offshored. Later in the study, this type of offshoring is identified as *Insourced Offshoring*.

2.4 Analysis of Global Sourcing

Now that offshoring has been identified as a choice of sourcing strategy, it can be better understood as it pertains to history, current trends, and key drivers or costs.

Offshoring is not a strikingly new phenomenon, but the onset of its use as a sourcing strategy is identifiable. The emphasis on global trade made possible by advancements in politics, technology, and international entrepreneurship are all factors that made LCCS a viable option. After World War II, manufacturing constituted over 25% of the U.S. gross domestic product; this value steadily decreased in the years following the War as manufacturers began to offshore their operations to foreign countries [12]. China's exports, remaining steadily slow in growth for several years, began to increase rapidly in 1991. This increase, in large part, can be attributed to a mainstream change in western manufacturers' strategy – investing in Chinese low-cost manufacturing [12]. As U.S. firms began to buckle to the increasingly popular Chinese LCCS trend, some companies sought other means to lower costs (e.g., increasing productivity, leaning supply chains, and honing core competencies). As a result, prices of manufactured goods in the U.S. have dropped 9% since 1995; meanwhile, nonmanufacturing prices of American goods have risen 22%. [12] The crux of most strategies aimed against offshoring point to an increase in productivity. Specifically, capital intensive manufacturing has substituted labor for long-term savings; this type of change to the U.S. manufacturing environment has resulted in an annual 2.9% increase in nonfarm productivity [12].

2.4.1 Structural Costs

As mentioned in the previous section, the theoretical concept of LCCS does not always translate into literal savings. For some companies, additional and unexpected

costs accumulate and make a foreign sourcing strategy lack major financial benefit. Since risks, not easily quantifiable to dollar amounts, are introduced through offshoring, a shift to foreign production with no major savings is an undesirable status. The methods for categorizing the many unexpected costs due to offshoring are numerous; however, one reasonably accepted nomenclature is "structural costs[13]," coined by economic consultant Jeremy Leonard. Structural costs are defined as "those out of manufacturers' direct control" and vary based on country [13].

A few examples of structural costs best describe Leonard's aim for the term. The major influence of labor unions in the U.S. drastically affects compensatory costs that manufacturing companies cannot easily alter. A financial executive's complaints of unions clearly describe a cost not under company control: "European and U.S. manufacturers are very unattractive particularly because of labor unions. The unions significantly increase costs for the companies that they work for and consequently make them less competitive in the global market" [10]. Another common structural cost involves regulation. The relaxed external regulation of industry in countries like China traditionally benefit low cost strategies; companies in these environments operate under lenient pollution policies, bear lower tax burdens through the omission of patent protection, and often face lax safety regulations [10]. Moreover, companies often are not quick to adhere to regulation policies because the likelihood or opportunity cost of violation enforcement is low [10].

An important finding in Leonard's report "The Tide is Turning" states that structural cost, comprised of categories such as corporate tax, tort costs, and required

[13] *Structural Costs* are those business expenses that must be accepted by the manufacturer based on the sourcing location. These types of costs directly relate to political standards of the sourcing destination. Jeremy Leonard defines structural costs as labor compensation, corporate tax, pollution regulation, energy prices, and tort litigation. [13]

employee benefits, are 17.6% higher on average than other countries[14] [13]. While the study gives an efficient overview of burdens U.S. companies face versus foreign competitors, it also displays other key concepts.

First, as indicated per the Raw Cost Index, or RCI[15], most foreign competitors are quickly gaining in compensation rate[16] versus the U.S. [13]. Much of the RCI growth in foreign markets can be attributed to low productivity growth. Common to developing economies, productivity losses often occur from external factors, such as power outages due to a lack of energy supply [10]. In addition, Leonard suggests that the rising cost of foreign labor is not an anomaly: "After a period of falling unit labor costs driven by capital investment, wages eventually will start to increase faster than productivity, which perforce leads to rising unit labor costs" [13]. Thus, the report suggests that business owners can expect compensation differentials between the U.S. and Southeast Asia to continue diminishing.

Second, corporate tax rates are the largest issue surrounding structural costs (over a third of the total 17.6%) [13]. However, even with the high, stagnant tax rate in the U.S., the average structural cost disadvantage reduced by 14.1% from 2006 to 2008 (the study's most current update) due to changes[17] in required employee benefits, tort costs, and environmental control [13]. This shift in the U.S. disadvantage brings about a major

[14] The countries used for this figure are the nine largest trading partners for the U.S. (Canada, Mexico, Japan, China, Germany, the United Kingdom, South Korea, Taiwan, and France) [13].
[15] RCI, or Raw Cost Index, is "defined as total wage and salary compensation scaled to manufacturing value added, and, thus, shows how much wages and salaries must be paid to produce $1 worth of output." In basic terms, the RCI is an effective way of measuring labor rate because it is based on productivity. By using RCI to transform labor compensation to RCI, comparisons between national labor rates lack low-productivity bias [13].
[16] The foreign compensation growth displayed in "The Tide is Turning" does not include exchange rate differentials. Since the U.S. dollar is currently generally weak versus major world economy players, the labor compensation growth in foreign markets would be different than listed in the report [13].
[17] While these changes are partially due to U.S. government efforts, some of the structural cost fluctuations from 2006 to 2008 resulted from policy changes in developing countries, where employee benefits and industrial regulation are increasing in a maturing labor market [13].

finding within the report: without the extra burden of structural costs, the U.S. would have an advantage over the majority of its largest trading partners [13].

2.4.2 Supply Chain Concerns

An important concept to remember about structural costs is their role in offshoring decisions. If structural costs in the U.S. continue on a path of reduction, the labor compensation savings may begin to lose their luster against additional costs inherent to LCCS strategies. While most labor rate differentials stay large between Southeast Asia and the U.S., lower structural costs could make the labor savings virtually insignificant after the addition of unavoidable supply chain expenses. Many companies that have issue with global sourcing may find that their resources, knowledge base, or product characteristics are unfit for international supply chains. These types of organizations generally have problems with supply chain management – a key to successful offshoring. For experienced companies, reducing holding and transit costs by maintaining low inventory levels is a valuable skill [14]. Another important characteristic possessed by seasoned supply chain professionals is understanding the role of taxes in LCCS strategy. Particularly, companies that operate among international borders closely monitor currency transfer risk[18]; since different tax structure and exchange rates apply internationally, internal transfer pricing is an important global tax concern [16]. David Jacoby of Boston Strategies International claims that companies struggling with LCCS normally have poor supply chain management; he suggests that supply chain management eventually becomes "the tail wagging the dog" [10].

[18] *Currency Transfer Risk* causes uncertainty in a cash flow due to transfer of funds between nations; this exchange subjects the cash flow to a volatile exchange rate [15].

Though supply chain costs are important to any firm participating in offshoring or other global sourcing strategies[19], they are not the only decision variable in the sourcing problem. In particular, risks and uncertainties need to be addressed. A Grant Thornton LLP study best sums up these "soft" costs: "Companies have come to realize that, in addition to hard costs, there are a lot of other risks and uncertainties related to global sourcing, which need to be factored in to a robust and informed approach to sourcing. Supply chain decision-makers are taking into account a variety of factors, not simply per-piece pricing" [16]. For instance, a break or disruption in the supply chain can be catastrophic to a business with required lead times. Contingency plans are vital for globally sourced supply chains that deal with political uncertainty, financial dynamics, and transportation accidents [17]. Furthermore, unplanned supply chain events scan drastically hinder daily operations. Business leaders who must deal with these issues often lack the time to address the fundamental sources of supply chain uncertainty and, instead, amend only the visible effects of undesired events [18].

According to a 2010 survey of 312 business professionals provided by Grant Thornton, 25% of respondents using outsourcing[20] had quality issues, 23% had on time fulfillment problems, and only 14% reported no major or recurring mishaps [16]. These types of statistics outline the risk and complexity that offshoring can offer to the supply chain. Moreover, other risks can be natural to the some offshoring locales: intellectual property infringement, a poorly regulated crime in China, generally receives unfavorable court rulings for offshored manufacturers. In the uncommon case that an issue reaches a court, the chance of a favorable judgment is 30% [10]. Problems from long-term effects

[19] *Global Sourcing Strategies* are strategies that use international resources to fulfill a need. Global sourcing strategies included intercontinental sourcing of production, or *offshoring*.
[20] In this case, "outsourcing" refers to companies that almost exclusively used global sourcing strategies (e.g., offshoring) [16].

like high labor turnover rate are highly difficult to quantify. 65% of respondents to an American Chamber of Commerce Study reported that labor turnover rate negatively affected their businesses in foreign environments (particularly in skilled and managerial workers) [10]. Within the same Grant Thornton survey, 44% of managers involved in global sourcing think that the strategy has not financially benefited their companies [16]. Though the effect of uncertainty in costs is somewhat expected, the number of managers that see negligible returns from this strategy is significant. LCCS is aimed at reducing costs; with nearly half of managers surveyed by Grant Thornton experiencing no cost benefit, the dynamics of offshoring display a need for further research and standardization. Grant Thornton suggests that U.S. organizations serving domestic customers will continue to move operations back or closer to home as these offshoring problems become clearer [16].

2.4.3 The Future of Global Sourcing

Since offshoring relates to several unpredictable and undesirable phenomena, understanding the future of low cost economies and global trade is fundamental to successfully navigating international sourcing. The Boston Logistics study "How Will Western Manufacturers Survive? The Art of High Cost Country Sourcing" outlines several "swing variables" that can have a dramatic impact on the effectiveness of LCCS: labor compensation increase, exchange rate reevaluation, low U.S. interest rates, increasing shipping costs, dual sourcing[21], and environmental concerns [10]. A particular change in these variables could make reshoring a necessary strategy for some enterprises. Though most of these variables are clear and already mentioned, a few deserve further

[21] *Dual Sourcing* refers to a company using two sources to fulfill a supply (or service) need. Normally, supplier redundancy aids in supply chain issue resolution [19].

discussion. First, because of its dependency on the oil market and significant contribution to Asian sourcing costs (approximately 20%), any positive fluctuation in shipping rates would certainly affect LCCS decisions [10]. Second, as China and other Southeast Asian nations become more developed, environmental standards may be created and affect LCCS strategies that take advantage of high-pollution manufacturing and shipping techniques [10]. In addition to the "swing variables" listed, Boston Logistics cites concern over politically driven domestic protectionist policies that could penalize LCCS strategies [10].

With all of the facts displayed about offshoring, a simple but important question needs to be answered: what exactly causes different companies to experience these similar issues? Most answers to this question probably relate to a misunderstanding of foreign manufacturing environments. Common characteristics of the manufacturing sector often differ between the favorite LCCS location, China, and the U.S. For example, only 25% of factories in China practice lean manufacturing, while nearly 70% of U.S. companies follow this methodology [5]. Even more, China's average production reject rate is significantly higher than the corresponding U.S. value (50, 000 ppm versus 100 ppm) [5]. With the margins of some global sourcing strategies relying on the variables Jacoby mentions, firms need to be able to evaluate current and future investments in the future. Companies must understand in detail the changing environment surrounding the offshoring problem.

2.5 Applying Research Methodology to Literature

The many aspects of the offshoring problem provide material for a detailed affinity diagram. The facts and concepts included in this preliminary diagramming step

relate not only to the costs, risks, and issues associated with global supply chains but also to potential solutions for quantifying and assessing the offshoring problem. Once the list of items about global sourcing problems and solutions is compiled, the affinity technique is applied: the concepts form different groups based on common traits. With a satisfactory level of organization reached, each category receives an overall title that reflects the common ground represented among the items. Figure 2.2 displays the results of the affinity diagram.

Cost Categories
Inventory
Energy
Obsolescence
Material and Components
Cultural Juxtaposition
Intellectual Property Infringement
Human Resource Training
Travel
Managerial Governance
Prototyping

Organizational Structure
Structural Contingency Theory
Functional versus Divisional Structures
Management Structure
Production Structure
Cross-functional Processes
Cross-divisional Control
Coordination Intensive Structures
Mechanistic versus Organic Structures
Degree of Collaboration
Degree of Mediation

Tools for Analysis
Failure Modes and Effects Analysis
Core Process Identification (via Enterprise Diagrams)
Value Chain
Value Stream Mapping
Key Performance Measures
Lean/Six Sigma
Moser's TCO Estimator
Enterprise Resource Planning
Simulation

Supplier Relations
Supplier Relationship Options (Long-term, contractual, or transactional)
Supplier Ability
Supplier Capacity
Dual Sourcing
Supplier Risk and Criticality

Supply Chain Management
Logistics
Length of Supply Chain
Visibility
Oil Market
Ownership

Supply Chain Decisions
Outsourcing versus Insourcing
Onshoring versus Offshoring
Nearshoring versus Reshoring
Push Production versus Pull Production
Consolidation versus Diversification

Human Resource Management
Productivity
Labor Turnover
Language Barrier

Customer Relations
External Customers
Internal Customers
Product Customization

Cost Characteristics
Hard/Soft
Complexity of Structure
Uncertainty
Quality
Sub Optimization
Lean Wastes
Perception
Traveling Salesman Problem

Intellectual Property Management
Innovation
Product/System Lifecycle
Intellectual Property Protection

Geographical Aspects
Clustering
Economies of Agglomeration
Decoupled Design and Manufacturing
Tax Structure and Incentives
Currency Appreciation
Transfer Pricing

Figure 2.2 Affinity Diagram

The first notable result of the affinity diagram is the identification of key roles in the firm: supplier relations, supply chain management, human resource management, intellectual property management, and customer relations represent *controlling* roles; these are the same functions as those labeled "secondary activities" in Porter's Value Chain . Porter's Value Chain[22], a process-oriented view of a firm or supply chain, is illustrated by Figure 2.3.

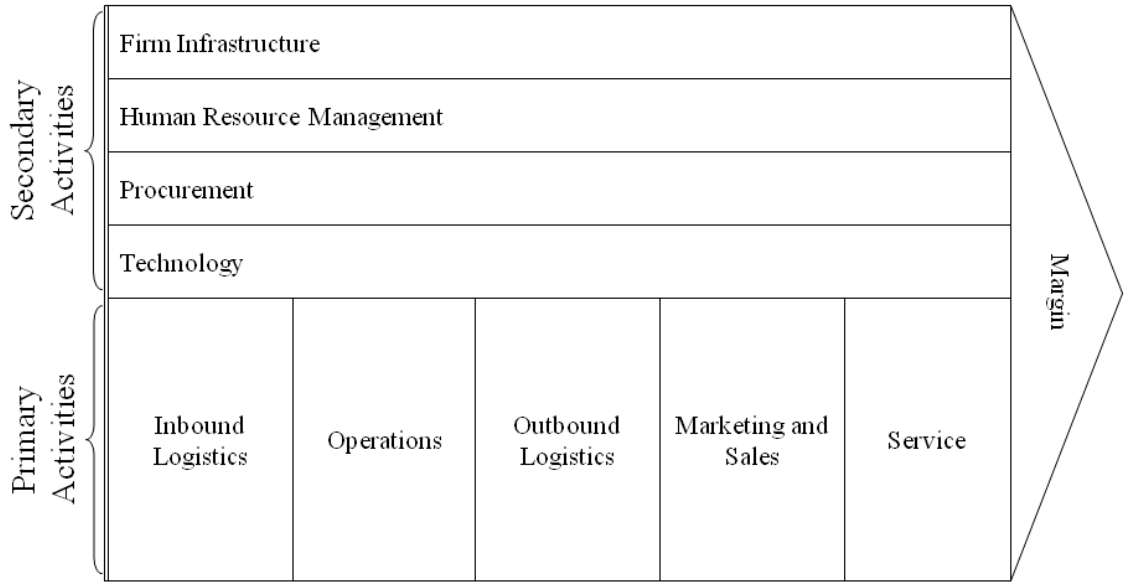

Figure 2.3 Porter's Value Chain

Note: Porter's Value Chain visually describes the generic components of the enterprise system. As described later, the relationships among these components (and subcomponents) is critical to addressing the offshoring problem [2].

Costs also pose a notable concern: while many types of costs exist, their characterization as "costs" may imply actual cash flows or causes of uncertainty[23] in cash

[22] Porter's Value Chain is "a comprehensive collection of all of the activities that are performed to design, produce, market, deliver, and support a product line" [20]

[23] *Uncertainty* implies a quantified value of *risk* or variability in a value; uncertainty can be expressed as a margin of error about an expected value or may imply a more detailed distinction through statistical distribution.

flow (i.e, risk). Costs and revenues resulting from a strategic choice need to be characterized in a manner that includes not only the cash flows associated with the enterprise arrangement but also with the risks that cause uncertainty in certain cash flow values.

While the secondary roles in Value Chain are identified by controlling roles in the affinity diagram, decision options that decision makers in secondary roles can make are numerous. Furthermore, organizational structure options make the array of decision options even larger; the aspects stemming from the organizational structure category suggest that the offshoring problem extends beyond the sourcing strategy. Offshoring is traditionally considered a sourcing choice, but these categories suggested the entire design of the enterprise warrants discussion.

Finally, the tools listed in Figure 2.2 provide several different options for evaluating the costs of a sourcing strategy. These choices range from qualitative tools, such as Value Chain Mapping, to quantitative methods, such as simulation.

CHAPTER III

THE COST BREAKDOWN STRUCTURE

3.1 Research Methodology

Since costs and uncertainty in cost are prominent issues to the offshoring problem as identified by affinity diagramming, a holistic view on the cost breakdown structure (CBS) is a necessary step in the study. To achieve this perspective, a basic CBS is defined, several current examples are examined, some issues with the current CBSs discussed, and then a new cost framework is defined.

Before the tenants of a holistic decision process can be defined, the views on sourcing costs found in the literature need to be analyzed. The reason that surveying different CBSs is important to this study is the research perspective that it provides. This tool illustrates not only the important cost structure of the sourcing decision but also the point of view that a decision maker has on this topic. Thus, the CBS describes what the industry leaders in global sourcing feel is pertinent to defining the offshoring problem. Firms and researchers that use a detailed list of costs based on industry experiences are critical sources of knowledge. The CBSs associated with these types of contributors provide some of the most useful information for this study and are analyzed in the following section[24].

[24] The referenced CBSs presented in the following pages represent quoted text that has been compiled in tabular format for the reader. In order to preserve the original work located in the tables, footnotes are used to provide point of clarification in each CBS.

The exploration of current CBSs serves the purpose of creating a holistic approach to a cost framework. In particular, Harry Moser's Total Cost of Ownership Estimator is the most complete tool for characterizing sourcing costs; however, the lack of focus toward interdependencies and variability in the firm and supply chain found in this tool does not align with the ESE perspective. Giachetti claims, "Complexity arises from not only the number of parts in the system, but also from the interrelationships of the system parts and the emergent behavior that cannot be predicted from the individual system parts." Thus, the focus on holism requires that the global sourcing CBS be focused on both cost and interrelationships among categorical variables. Because of this research avenue, a hierarchal categorization structure provides a logical means for sorting not only fundamental cash inflows and outflows but also sources of variability. In this chapter, a basic CBS, presented in the following section, is transformed into a systems-oriented CBS based on industry perspectives in supply chain costs and risks inherent to global sourcing. In later chapters, the notion of the CBS is promoted to the concept of a dynamic model that interacts with other valuation components.

3.2 A Basic Sourcing CBS

The CBS of a manufacturing sourcing strategy represents the fundamental components of a critical performance metric – cost. Thus, the purpose of this financial "framework" is to provide an outline that encapsulates all of the cash flows that occur in a strategy under consideration. Not unlike a common project or product CBS, the cost framework for a manufacturing sourcing strategy contains an itemized list of cost categories associated with production and product delivery. Table 3.1 describes a basic

CBS for a sourcing strategy in which costs are generally labeled as unit costs and overhead.

Table 3.1 A Basic Manufacturing CBS

Cost Type	Costs
Direct Costs	Direct material, direct labor, freight, inventory, direct energy
Indirect Costs	Indirect material, indirect labor, indirect energy, taxes, facility maintenance

The preceding CBS represents the most primitive case for a cost structure: certain costs correlate to the amount of units sold while others normally occur as overhead (i.e., not highly related to units sold). The objective of managers selecting a sourcing strategy is to minimize the costs in Table 3.1. This CBS and its objective represents the traditional, non-ESE perspective. Conversely, the major differences between the basic CBS and a holistic global sourcing CBS are the inclusion of many risks and an overall focus on total cost. Minimizing the total cost (or maximizing the total value) is the goal of the systems view approach to the sourcing problem.

The realization that a global sourcing CBS should contain much more than basic cost considerations brings forth major issues with the current practices of offshoring. The main issues with basic CBSs are twofold:

1. The CBS is designed to encompass unit costs of production rather than dealing with the total cost of fulfilling customer orders, and
2. The CBS does not address the effects of risks along a global supply chain [11].

Stated simply, experienced decision makers consider that the total cost of a supply chain is highly dependent not only on the number of units sold but also on other supply chain variables such as the price of oil. Though a cost such as shipping relies on the number of

units shipped, its relationship to oil, a commodity characterized by volatile prices, is also of great importance. Even though startup, maintenance, shipping, issue resolution, and disposal costs should not be neglected for any product manufacturing system, these types of cost have potential to be larger in a globally sourced supply chain (as mentioned in Chapter II).

3.3 Emergent Industry Views on Costs

Industry leaders and consulting groups provide a wealth of knowledge to the issue of the CBS for global sourcing. Their experiential knowledge forms the basis for their emergent cost frameworks. Of the current CBSs discussed in this study, all of them generally fall into two categories: risk assessments and full CBSs. A risk profile is truthfully not a complete CBS but does represent the first step toward constructing a bona fide framework of costs; therefore, they are included in the discussion provided in this section.

3.3.1 Risk Profiles

Risks are the underlying importance for the CBS of an offshoring strategy; essentially, the risks common to global supply chains intensify the need for total cost focus. The decision maker's ability to understand the ways to incorporate important risks into his or her final assessment of a strategy is more likely to make successful decisions. The first risk profile discussed (Table 3.2), provided by Chopra and Meindl, breaks down the common areas of risk associated with any general supply chain design.

Table 3.2 Supply Chain Risks [11]

Risk	Risk Driver
Disruptions [in the supply chain]	Natural disaster, war, terrorism, labor disputes, supplier bankruptcy
Delays [in supply]	High capacity utilization at supply source, inflexibility of supply source, poor quality or yield at supply source
Systems Risk	Information infrastructure breakdown, systems integration or extent of systems being networked
Forecast Risk	Inaccurate forecasts due to long lead times, seasonality, product variety, short life cycles, or small customer base; information
Intellectual Property Risk	Vertical integration of supply chain, global outsourcing and markets
Procurement Risk	Exchange rate risk, price of inputs, fraction purchased from single source, industry-wide capacity utilization
Receivables Risk	Number of customers, financial strength of customers
Inventory Risk	Rate of product obsolescence, inventory holding costs, product value, demand and supply uncertainty
Capacity Risk[25]	Cost of capacity, cost of flexibility[26]

Table 3.2 provides a logical starting point on risk assessment because it analyzes a general supply chain design; though not all supply chains may be subject to each component in Table 3.2, the large scope of the list helps to describe the complex network of relationships at work in a global supply chain. Of the risks listed, some of the notable items include considerations on understanding supply delays and supply chain disruptions, dealing with procurement phenomena, and realizing the criticality of intellectual property protection. These categories are probably not a focus in most decisions during the design of a domestic production system (i.e., those types of problems

[25] "Capacity Risk" refers to the risks associated with the price of adding capacity and flexibility to a production system. Adding these components to an offshore facility may be costly. [11]
[26] *Production Flexibility* refers to a manufacturing system's ability to adjust to different levels of production capacity and to accommodate a diversified product portfolio.

are related to the global nature of an offshored manufacturing unit). However, these considerations need to be included in the holistic CBS.Table 3.3 takes the analysis of offshoring risk a step further by listing potential issues that relate specifically to global manufacturing. Calvin Beyer, an expert on global manufacturing risks, proposes this categorization of risk[21].

Table 3.3 Total Risk Profile [21]

Risk	Explanation of Risk[27]
Risk of Natural Disasters	Evaluating the potential of a foreign country and the locations of your production partners for the expected frequency and severity of natural disasters, such as hurricanes/cyclones, earthquakes, seasonal flooding and tsunami events, and volcanoes
Manmade and Technological Risks	These include quality of electrical power, telephone and other utility systems; water sanitation, and transportation infrastructure; proximity to hazardous waste sites and nuclear power generation stations, etc.
Compliance Risks	Such as the consequences of not meeting accounting, legal, tax, environmental, and other regulatory requirements, as well as not complying with ethical standards associated with business practices
Insurance Risks	Either outsourcing or offshoring production will be concentrated in the areas of adequate coverage and limits for transit and contingent business income (CBI[28]) from dependent premises.

[27] The stylistic inconsistencies in this category are a reflection of quoted explanations of risk found in "Improving Your Strategic Sourcing Decisions: Total Cost of Ownership and Total Risk Profiling" [21].
[28] Calvin Beyer states "CBI can provide worldwide coverage for a manufacturer whose named or unnamed suppliers (depending upon policy terms and conditions) suffer a named property peril resulting in a supply chain disruption that causes a loss to the manufacturer's income from the disrupted production" [21].

Table 3.3 Continued

Political Stability of Country	Consider factors such as the stability of the country and the region, trade policy challenges such as embargoes, and excessive or changing regulatory statues
Economic Stability of Suppliers	Risks from raw material dependencies, labor availability, as well as stability of the suppliers' suppliers
Lost Opportunities	Potential lost orders, lost customers, and slow customer response times if the supply chain is disrupted
Product Liability and Non-Recovery Cost	Companies have limited to no recourse in the ability to collect economic and other damages for breach of contract or in legal suit or subrogation for product liability claims
Quality Risks	These include the cost of resourcing parts or reworking products that do not conform to specifications or that need to be withdrawn from the market due to voluntary or forced recalls
Intellectual Property Risks	Trademark, copyright, and patent infringements from counterfeiting and loss of shared knowledge or best practices
Transportation Risks	Port strikes, piracy, mishandling and damage during shipment, and the cost of emergency air freight to obtain critical parts
Reputation Risks	Damage to your company's brands and corporate reputation and the costs associated with brand and reputation restoration, including crisis management communications and public relations expenses

Table 3.3 is a clear example of experiential knowledge; the risk profile details several considerations uncommon to the basic CBS. A few items that go beyond the risk profile in Table 3.2 include technology infrastructure, regulatory compliance, insurance, liability, quality, and marketing concerns. The elaboration of these categories displays areas that the decision maker must explore in order to understand the value of a global manufacturing strategy. Another important concept discussed in Table 3.3 is the benefit from examining the stability of tier 2 or tier 3 suppliers [21]. These types of risks need to be numerically related to the new CBS provided by this study.

3.3.2 Cost Breakdown Structures

With current risk assessments explored, the analysis focuses on full CBSs. The first item discussed is Leonard's structural costs (Table 3.3). Structural costs are those "out of the manufacturer's control" and include

1. Corporate Taxation,
2. Employee Benefits,
3. Pollution Abatement,
4. Energy Prices, and
5. Tort Litigation [13].

Structural costs are important because they represent the primary areas in which corporations save[29] money when they use offshore manufacturing. Employee compensation is usually the most common discussion point for offshore savings, but these other categories can often be equal or better than domestic situations. (Leonard points out that corporate taxation in particular is a glaring negative toward choosing to locate production in the United States [13].) . Thus, the systems approach to a CBS should display savings for offshore strategies in categories governed primarily by structural costs.

Exhibiting a more detailed CBS than just the structural cost point of view, Table 3.4 illustrates a broader perspective from the previous list by defining the Total Cost of Ownership (TCO) for offshore production.

[29] Of those categories listed in the structural costs, energy prices are sometimes cheaper in the mainland U.S. due to the need for local generation backup at foreign facilities [22]. In any case, Leonard's study indicates that energy prices make up a less significant portion of the total structural costs [13].

Table 3.4 Total Cost of Ownership [22]

Category	Costs
Direct Product Costs	Material, labor, capital and depreciation, energy
Indirect Costs[30]	Overhead, profit margin
Non-price TCO Components [i.e., new costs from offshoring]	Prototyping, packaging, freight, expedited freight, inventory carrying costs, additional quality management, end-of-life obsolete inventory

Table 3.4 illustrates the relationship that offshore savings has to product costs: structural costs (i.e., the primary opportunities for lower foreign costs) are generally related to the product (per unit); meanwhile, the "Non-price TCO Components" are the categories that companies tend to experience new costs from offshoring. *New* categories of cost from offshoring are a major concern; Table 3.3 essentially separates costs based on categories more inclined for savings and those that provide new offshoring expenses.

Harry Moser's TCO Estimator is the next CBS considered (Table 3.5). The Estimator's organization is a refined version of the ideas displayed in Table 3.4; this CBS is perhaps the best example of a "template method" cost breakdown currently available for public use in this industry; that is, his work is not only significant because of the cost perspective but also because of the applicability of this tool to industry [23]. Most notably, Moser has improved uncertainty quantification[31] in the CBS by including specific categories for risky situations.

[30] "Indirect Costs" in this case are considered not to be a true unit cost but instead are each based as a portion of the total "direct product cost."

[31] The many ways to deal with the numerical inclusion of risk (i.e., the quantification of uncertainty) in valuating strategic options is a topic of later sections; in Chapter III, the discussion of risk is primarily focused on categorization and the current methods used rather than the preferred numerical characterization techniques.

Table 3.5 Total Cost of Ownership Estimator [24]

Category	Costs
Cost of Goods Sold	FOB price, packaging, duty, fees (flat and rate), routine surface freight (excluding local), routine air freight (excluding local)
Other Hard Costs	Carrying cost for in transit offshored product if paid before shipment, carrying cost for inventory onsite, prototype cost, end-of-life inventory, start-up travel, auditing/maintenance travel, pick/place into local inventory, purchasing cost (excluding travel)
Risk[32]	Emergency air freight, reworks/quality, product liability non-recovery risk, IP risk, opportunity costs (lost orders, slow response, lost customers), economic stability of supplier, political stability of the country
Strategic	Impact on innovation of distance from manufacturing to research and development, impact on product differentiation or mass customization
Green	Production, shipping, local warehouse, travel, disposal of obsolete inventory
Forecast	Wage inflation, currency appreciation

The most noticeable difference between this CBS and all others is the specificity of each category; Moser leverages experience to provide a list of items that tells users exactly the types of costs a particular category entails. Strategic risks such as diminishing innovation and green manufacturing perception are considered as costs bound to increase from offshore sourcing. In addition, Moser includes exchange and wage inflation rates such that the users of the TCO Estimator can see long-term forecasts of costs; both of these rates should be included in any thorough cost study on a global sourcing strategy. Moser's TCO Estimator is the primary categorization source for the eventual CBS displaced in section 3.5. His categorization of risk, though, is scrutinized before reaching that stage of research.

[32] The risks listed in this and the "Strategic" categories are calculated as a percentage of the FOB price.

3.4 Shortcomings of Current CBSs

The current CBSs displayed in the preceding section are a logical starting point for dealing with a problem as complex as global sourcing, but a few key items are missing from the discussion. With planning horizons of several years, analyst and executive decision makers may be unprepared to quantify every cost issue if they are inexperienced in global sourcing. With this point mentioned, the overall goal for managers faced with these decisions is that they should hope to reach a level of experience that enables them to understand each cost mentioned in Table 3.5.

Each CBS fails to recognize the ways that risks manifest into a CBS. Risks, from a financial perspective, enter into a cost model as an "uncertain input," a variable that ideally can be characterized stochastically [25]. Though the TCO Estimator's detailed risk inclusion represents progress, the expression of uncertainty as separate items that sum with assumed deterministic categories is not a mathematically consistent method. An uncertain variable, such as the price of oil, cannot be addressed by adding a new cost category. Instead, users need to know how a new or unexpected fuel cost may affect several related categories in the CBS. Though this method is a more complex approach to the CBS for the offshoring problem, including risks in other manners seems to downplay the importance of *interdependencies* in the supply chain. In order to deal with the relationships inherent to the enterprise, the CBS's structure should accommodate the relationship focus in systems theory. Therefore, without acknowledging that all of these costs are highly dependent on several variables, the perspective on a particular strategy could be completely misguided.

3.5 A Holistic Cost Breakdown Structure

Offering a CBS for global sourcing is a detailed task. In this section, a structure is provided that encompasses both costs and revenues; thus, the objective of the firm is to minimize the value of this CBS. (Revenue is a negative cost.) The process for generating the holistic CBS is to start with the basic cost framework in Table 3.1,to review other structures from experienced decision makers (particularly, the TCO Estimator), and to add new features (or add components to previously simple categories). The decision maker must note that this step (as well as most other procedures outlined in this study) should always be tailored to the situation in question. The makeup of the new structure is not representative of a specific firm; hence, businesses may wish to customize the CBS to fit their sourcing situation if it differs greatly from the presented information.

The new CBS is the sum of all the components in the following list:

1. Revenue
2. Direct Material
3. Direct Labor
4. Direct Energy
5. Transit
6. Inventory
7. Reorders, and
8. Indirect Costs.

In place of including separate categories for risk incorporation, each major category of cost (again, primarily based on the TCO Estimator) is related to several input and control variables. (Later, the uncertain variables can be quantified based on potential risks as discussed in the proceeding chapters). Figure 3.1 displays a relationship-focused

CBS that addresses the basic interdependencies found in the offshoring problem. (Only direct costs are included in this diagram; indirect costs, discussed in Figure 3.9, offer more complexity and differentiation among specific industry examples.) The figures following the new CBS display the hierarchical relationship of variables among each primary cost categories. A note after each figure describes some of the important characteristics of a category.

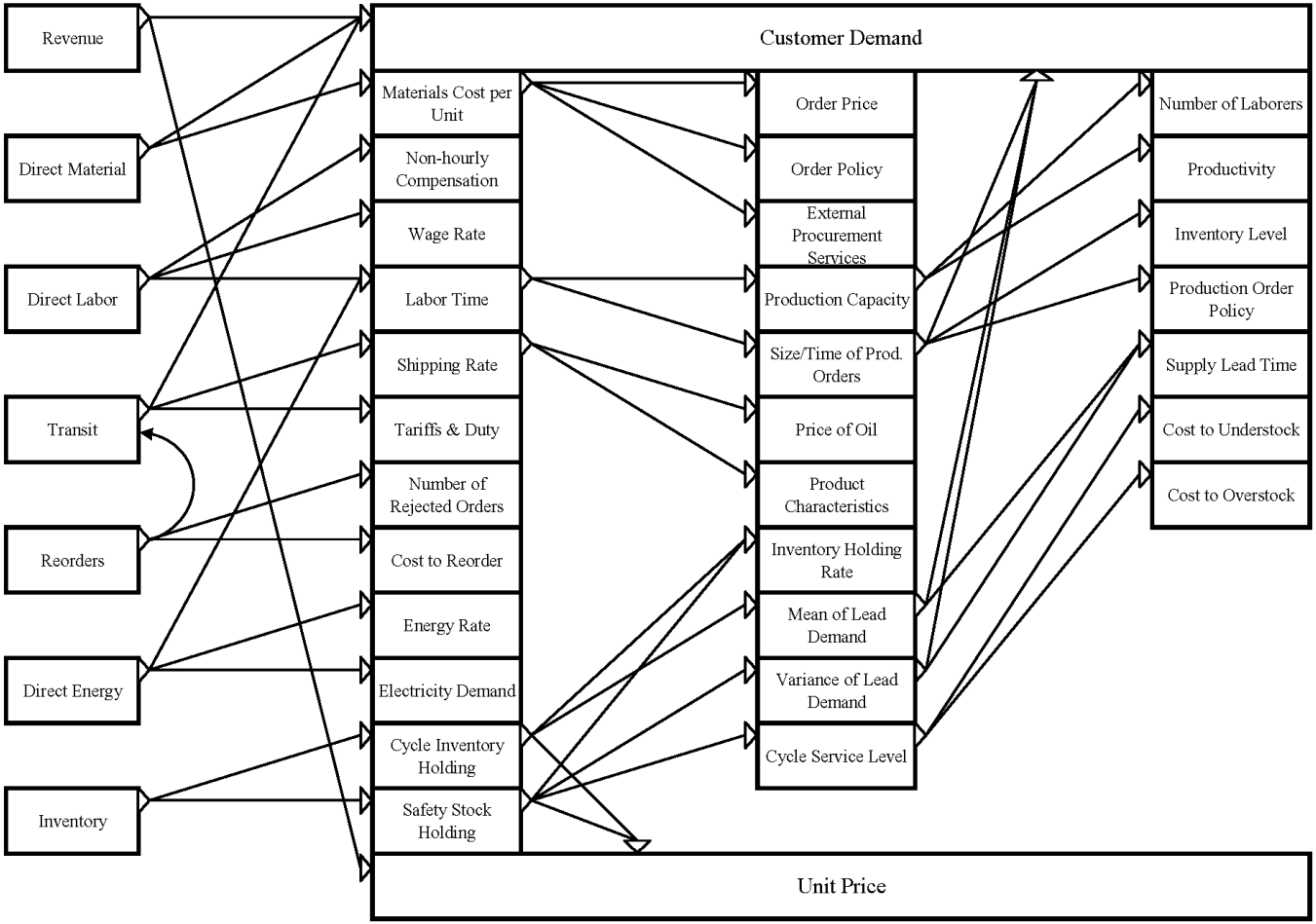

Figure 3.1 Cost Structure for the Direct Costs of Offshoring

Note: The figures following this diagram contain explanations of each primary cost category.

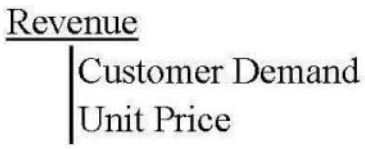

Figure 3.2 Revenue

Note: Revenue is the product of units demanded and unit price. The revenue represents a negative cost in the CBS.

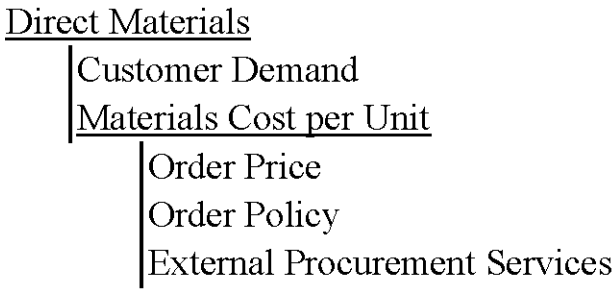

Figure 3.3 Direct Materials

Note: Direct Material costs are the units demanded times material per unit. Material per unit is a function of several possible variables. Some suggested components are order price, order policy, and any external procurement service transaction fees.

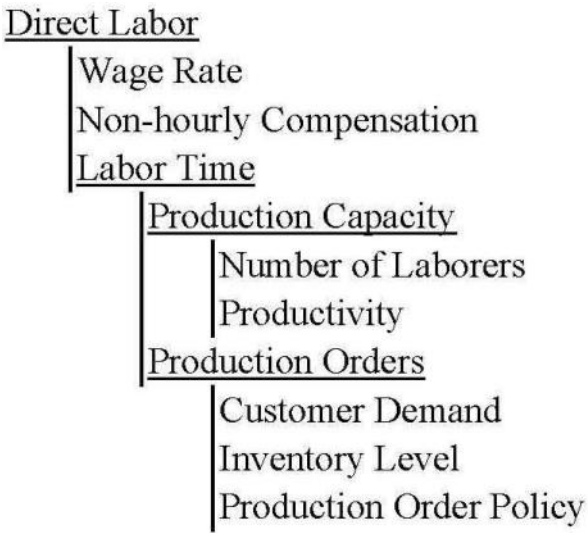

Figure 3.4 Direct Labor

Note: Direct labor is the product of wage rate and labor time plus other employee compensations. The break-down of labor time differs among companies; however, the illustrated method defines production capacity (which may reflect a labor force size and automation capabilities) and number production orders (which should be tied to units demand, current inventory level, and the production order policy). Defining labor in this manner may provide the ability to account for the productivity disparity between countries as mentioned by Leonard.

Figure 3.5 Transit

Note: Transit costs are the number of units shipped, which relates to the number of units demanded, times a shipping rate plus any other tariffs or duty. The shipping rate is dependent on the price of oil as well as product characteristics, such as weight and volume. Unlike the TCO Estimator, the price of oil is directly included in the new CBS.

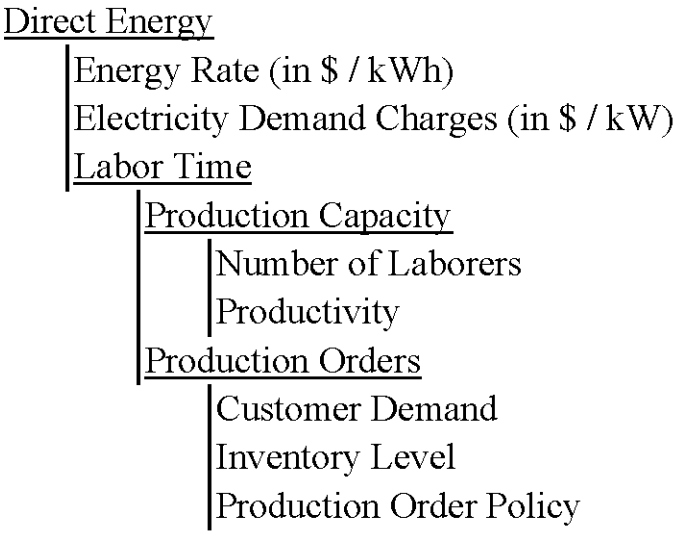

Figure 3.6 Direct Energy

Note: Direct Energy cost is the energy rate for both electricity and natural gas times the labor time plus any additional electricity demand charge. Again, labor time is a function of production capacity and production orders as mentioned in Figure 3.4.

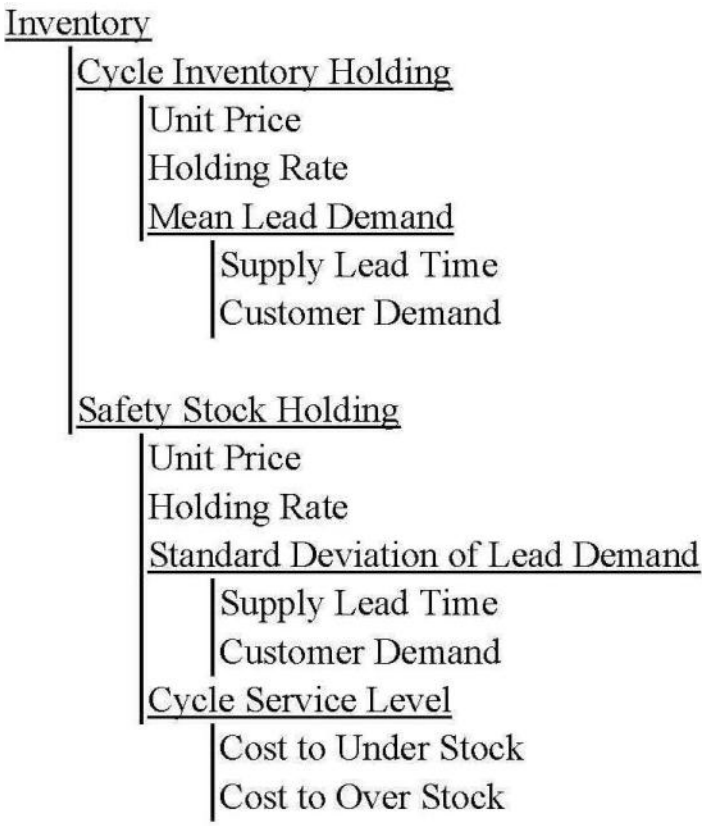

Figure 3.7 Inventory

Note: Inventory costs are the sum of holding cost for cycle inventory and safety stock. Cycle inventory cost depends on the unit price, a defined holding rate, and the mean lead demand. Lead demand is a function of supply lead time and units demand. Meanwhile, the safety stock holding is also dependent on unit price and holding rate but relies on the standard deviation of the lead demand. In addition, the cycle service level[33], determined by the costs to under stock and to over stock, must be defined by the company. The method for quantifying inventory costs is based on Chopra's and Miendl's *Supply Chain Management* [11].

[33] The cycle service level represents the percentage of demand requests that are served without significant delay.

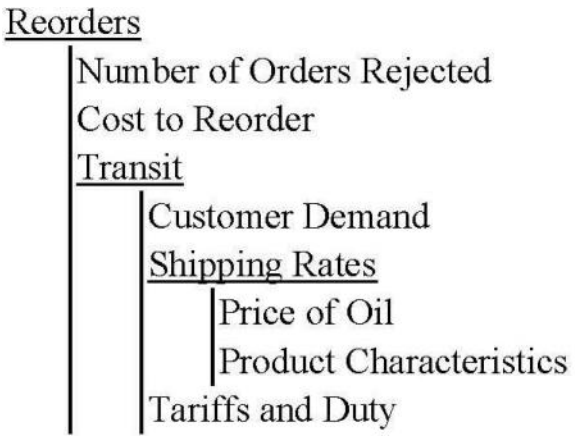

Figure 3.8 Reorder Costs

Note: Reorder costs are the number of orders rejected times the sum of reorder and transit costs. The cost to reorder depends on several factors including the cost of the production order, customer perception issues, etc. (Since this category is unique to most companies, elaboration on the cost to reorder is omitted for brevity.). In addition, transit cost appear similar to Figure 3.8; however, managers should note that if reorders employ other means of transportation than usual (e.g., air instead of sea freight), then this category should reflect those differences. (Moser also addresses the chance of more costly emergency freight requirements in the TCO Estimator[24].)

Figure 3.9 Indirect Costs

Note: Indirect Costs are those that do not directly relate to the fulfillment of customer requests. This category may differ significantly among different strategies. Nonetheless, some permanent features in Figure 3.9 are taxes, which are separated between foreign and domestic codes; travel costs, which include routine travel of managers from a domestic headquarters to the manufacturing facility; and additional quality control, which implies that some foreign strategies require more intense quality control features that may be more expensive to implement. Many of these categories are mentioned by the TCO Estimator [24]. Once a company defines each of these components for indirect costs, management should attempt to quantify hierarchical relationships similar to Figure 3.1. As a result, the company would understand the sensitivity of indirect costs to uncertain input variables.

The detail shown in the preceding figures presents a large amount of work for the decision maker. The specificity of an offshoring strategy may not reach this level before making a decision; however, the relationships described are important for the decision maker to understand. If the level of uncertainty exhibited by many of the inputs listed is significant, decision practices that are based on a wage rate "threshold" for savings can have some major setbacks (i.e., the concept which states, "if 'x' percent of labor costs can be saved, then offshoring is the best choice" is invalid). In order to organize better

the important notes about the new CBS, the following list mentions notable characteristics.

1. Cash flows are never labeled as pure "unit" costs. Realistically, cost may not perfectly correlate to the volume of production. For example, direct labor is generally assumed to be a unit cost, but the large discrepancies in compensation agreements between developed and developing countries can significantly affect the final sum of labor payments. Therefore, the important relationship for labor costs goes beyond units of production; global production strategies need to be examined based on total compensatory costs. Other categories exhibit similar characteristics.
2. Several fundamental variables exist in multiple categories. If a base component is shared among several cost categories, a decision maker may justify spending more time characterizing that variable accurately. Customer demand illustrates this concept and is probably a key variable in quantifying a strategy's subjection to global volatility.
3. The price of oil is directly included under the "Freight" category. The savings gleaned from operating in a globally sourced supply chain is always dependent on the oil market. Therefore, if the margin of savings is slim for an offshore option, a foreign strategy could prove ineffective.
4. The "Direct Material" and "Inventory" categories provide information not only in cost figures such as material order pricing and inventory costs but also in working capital. In general, situations with a high finished product value and a bulky inventory system require a large amount of working capital. (Though not

included as a part of the CBS, working capital is a metric that can be measured via the proposed simulation technique discussed in Chapter V.)

5. The costs to under stock and to over stock are design variables. These items are used to dictate the Cycle Service Level, which usually defines the inventory policy for a company. The opportunity lost from orders that cannot be filled due to shortages is included in this figure and should not be restated in additional opportunity cost considerations.
6. The annotated Porter Value Chain (Figure 3.9) displays that the main cash flows[34] described by Figure 3.1 manifest in primary functions. Meanwhile, the "Other Categories" are most associated with the secondary activities. The quantification of these miscellaneous costs is not straight-forward, deals with many unknown and unique interdependencies, and varies greatly in magnitude depending on many product and environmental characteristics.

[34] The "Reorders" category is represented across the entire primary portion of the value chain. For brevity, this category is omitted from Figure 3.2. Similarly, indirects costs are most likely to occur in secondary functions.

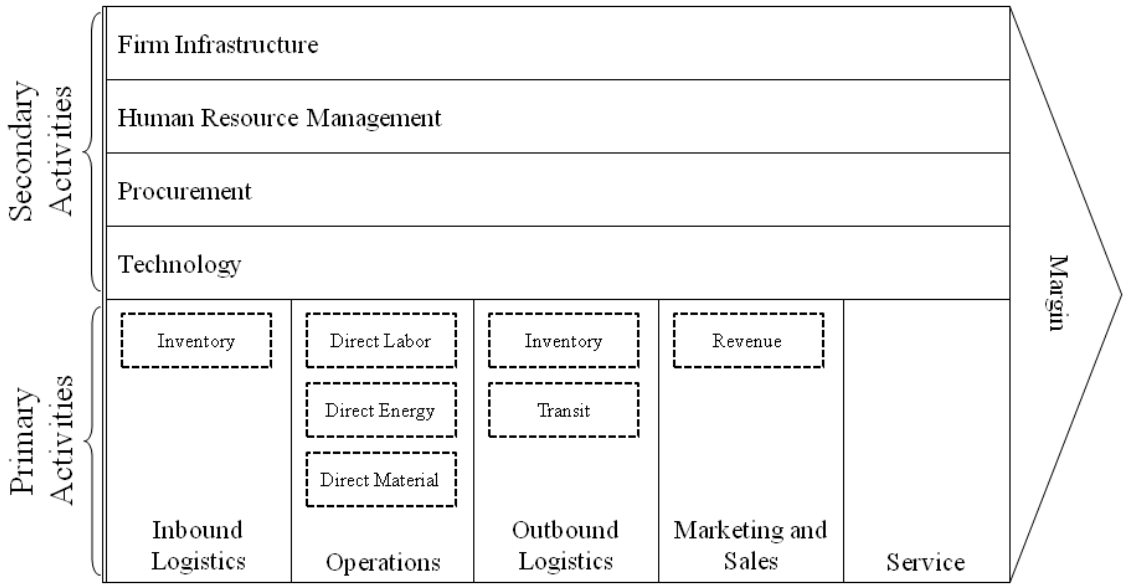

Figure 3.10 Cost-annotated Porter's Value Chain

The new cost breakdown structure emphasizes a holistic viewpoint that focues on interdependences within the firm and the supply chain; however, the CBS is only a part of a large decision methodology that evaluates different options for sourcing the manufacturing function. In the next chapter, the components of the decision mesh with the CBS to provide the groundwork of valuating offshoring and domestic strategies. Furthermore, the next sections offer the concept of a CBS as a "Cash Flow Model," which defines the interaction that finances of a sourcing strategy have with uncertain variables and control variables[35].

[35] *Control Variables for Strategy* numerically defines a strategic option. Common categories of control variables include flexibility controls, target demographic choice, perceived product characteristic value, and labor compensation rate for a location.

CHAPTER IV

THE GLOBAL SOURCING DECISION

4.1 Research Methodology

In this chapter, analysis of critical sourcing issues serves as a means to create a procedure for approaching a decision. To reach the final product of the decision methodology, the study first focuses on the reasons for needing a defined decision technique; then, the analysis addresses several prominent issues to global sourcing. Throughout the exploration of these topics, some ESE tools (particularly, Porter's Value Chain) are used to provide systems perspective toward the issue at hand. In addition to analyzing pertinent matters of the sourcing decision, several strategies, sourcing or otherwise, are examined. Through understanding the positive and negative aspects of different strategies applicable to the situation, the study enables the illustration of a new, detailed decision technique that lends itself to the core principles of ESE.

Throughout Chapter IV, the analysis of sourcing exhibits process focus. Essentially, the ideals of process improvement, often a subject of the manufacturing floor, are applied to the corporate decision. Process management[36], then, defines the role of the decision maker. Based on the work of Joseph Juran, process management includes the design, control, and improvement of a business entity; understanding these three roles is essential to meeting high quality operations, to discovering areas in need of

[36] *Process Management* includes the design, control, and improvement of a business entity; understanding these three roles is essential to meeting high quality operations, to discovering areas in need of improvement, and to meeting high customer expectations. Process Management stems from the "Quality Trilogy" founded by Joseph Juran. [26]

improvement, and to meeting high customer expectations [26]. The following decision method focuses on all three aspects of process management; though the decision exists primarily as a design step, the formulation of different strategic options follows all three steps in Juran's "Quality Trilogy." The decision maker should continuously hone strategic choices to reflect a customized plan fit for the situation. The emphasis on process management enables decision makers to design emergent strategies developed for future deviations from the status quo. In order to reach the outcomes of the study, a particular problem identification method applicable to process management, the enterprise diagram, relates an abstract concept of strategy selection to a concrete business structure.

The technique resulting from this study separates the decision into four clear steps such that tasks are portioned to the proper members of the corporate decision team. At the conclusion of Chapter IV, the decision process offers a basic model architecture that a later chapter addresses.

4.2 The Need for a Defined Decision Technique

When a group of managers is evaluating different options for sourcing the manufacturing function, the choices of strategy are numerous. Due to the overwhelming amount of information that must be interpreted in order to make the sourcing decision, a clear and methodical process for analyzing the different options needs to be available to managers. Currently, few contributors to the field take time to discuss the approaches to weigh different options – most emphasize the important categories of a cost breakdown structure (CBS) or a numerical method for cost valuating the strategy. Though both of these concepts are vital to making the decision, a systems perspective on the topic

provides a better chance at making a well-rounded choice that lacks bias toward a small component of a large problem.

Four main types of sourcing describe the basic choices available for the sourcing of production. These archetypes of the manufacturing arrangement vary based on location of the facility and ownership of the function. Described by Figure 4.1, the four options entail some general product and organizational characteristics for most companies.

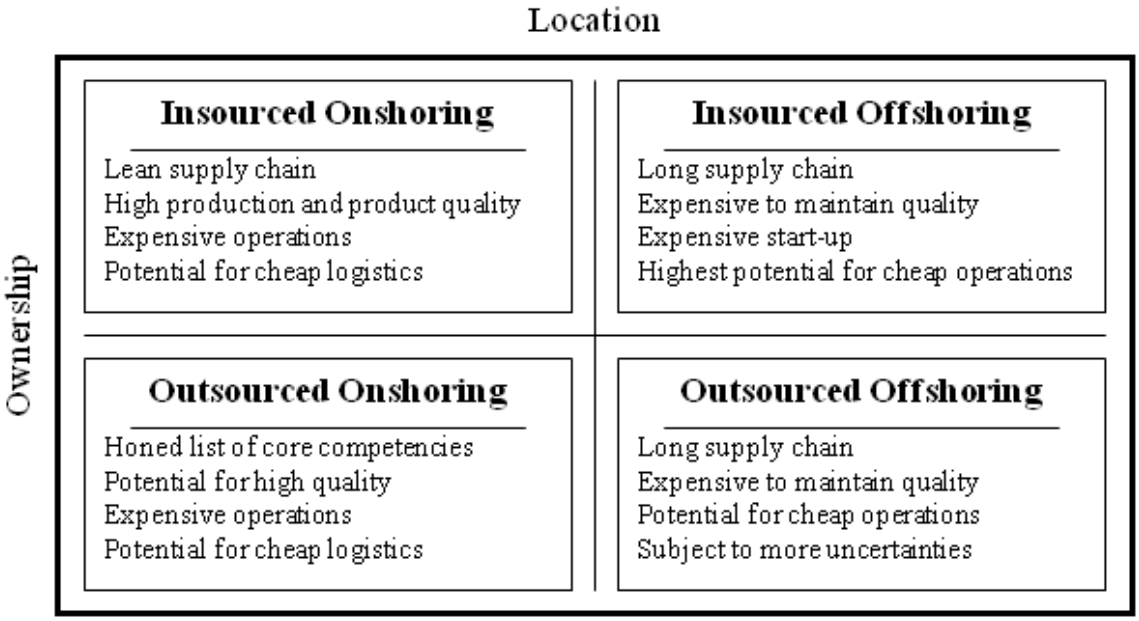

Figure 4.1 The Sourcing Matrix

Note: The affinity diagram in Chapter II led to the creation of this figure. The "Supply Chain Decision" section offered several general strategic choices; the variability between ownership and location became evident while forming the affinity group.

Within this study, insourced offshoring[37] is the main type of sourcing discussed; however, the concepts provided are valid for outsourced offshoring[38], insourced

[37] *Insourced Offshoring* is the vertical integration of a global supply chain; large companies that own an intercontinental manufacturing facility pursue an offshore insourcing strategy.
[38] *Outsourced Offshoring* is exhibited by companies that use intercontinental manufacturing facilities but purchase the production service from a third party.

onshoring[39], and outsourced onshoring[40]. In fact, an agile technique for assessing the different sourcing options is best because of the sourcing choice's variable nature – the differences among strategic options are vastly significant. Thus, the conceptual basis for the evaluation methods defined in a later section can accommodate many unique options.

A fitting way to start the discussion of the decision technique is to answer an important question: Why do companies look to offshoring? In most cases, the answer is simply to save money (potentially against firms that offer lower prices gleaned from global manufacturing). Therefore, the bottom-line goal of a decision methodology for the sourcing of manufacturing should be to point toward the lowest cost method; however, the labor cost of an option is only a single metric. As Giachetti mentions, complex systems cannot be described by a single part; similarly, decisions cannot be made for the system based on one component [2]. The total value of a particular strategy is a much more complex issue composed of market forecasts, long-term marketing assumptions, and product lifecycle predictions, all in addition to a detailed financial review.

Although four major choices are outlined in Figure 4.1, the options for overall strategy are not as simple to categorize. The reason for the myriad of decision options available for a manufacturer lends itself to the concept of strategic fit[41]. The Sourcing Matrix only outlines the major archetypes for the manufacturing sourcing strategy, but the competitiveness of a company stems not only from good sourcing practices but also from good corporate-wide policies. In other words, the sourcing strategy is a fundamental component of the corporate-wide strategy and should not be separated (in

[39] *Insourced Onshoring* is the vertical integration of supply chain activities. In the case of this study, onshore insourcing represents a company that owns its manufacturing facility.
[40] *Outsourced Onshoring* is a company's purchasing domestic services to fulfill a function outside of its core competency.
[41] *Strategic fit* is the collaboration of all company (or value chain) strategies [11].

the decision process) from the overall corporate mission and vision. To alienate via distance the production process from a company that specializes in delivering manufactured products can be risky if the corporate-wide strategy is not earnestly arranged to deal with geographical or ownership disparity. A choice of the lowest cost sourcing strategy at the expense of total corporate worth is an example of sub-optimization. These concepts lead to a vital component to any successful decision methodology for the manufacturing function: a decision about production should reflect not only the greatest value from an operational standpoint but also the greatest value from an organizational perspective.

In fact, the sourcing decision is not even a total reflection of the supply chain strategy. Sourcing production only includes the manufacturing functional group, but the supply chain also draws attention toward logistical features of Porter's Value Chain (Figure 4.2). Moreover, the supply chain strategy is only a component of three primary strategies: product development, supply chain, and marketing and sales. Those three parts mesh with secondary strategies (e.g., information technology) and the top-level competitive strategy to achieve the strategic fit of the company. [11]

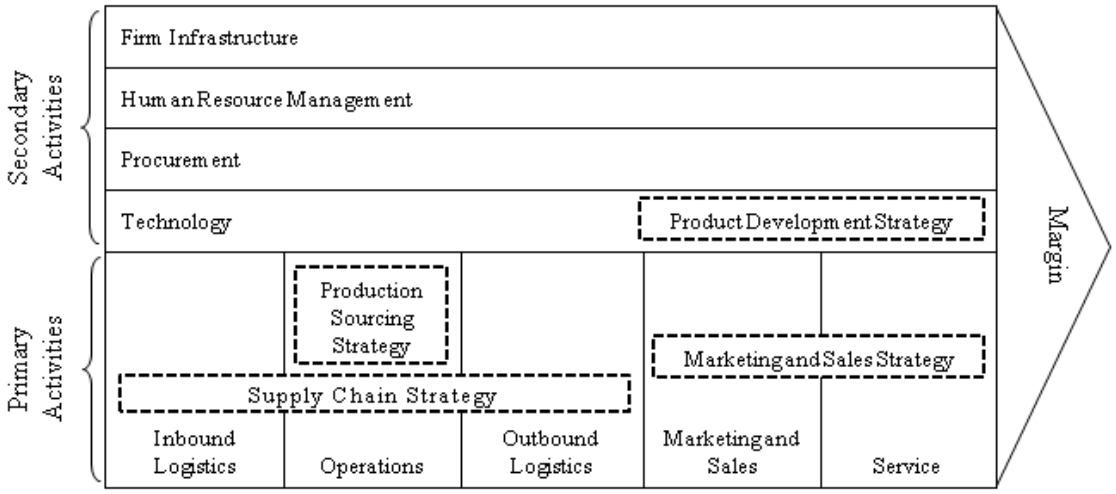

Figure 4.2 The Value Chain and Strategy

Note: The Value Chain represents all of the steps toward serving the customer, but the figure illustrates that the production sourcing strategy is intended generally to control one component (operations). However, the complexity of the enterprise system entails that changes in some areas of the company are bound to affect other components of the company [2]. An offshore production strategy may entail major changes to other components in the value chain.

To achieve synergy among strategies, the decision maker must match the needs of the customer with the uncertainties and capabilities of the supply chain [11]. This reason is potentially the crux of all failed offshoring projects; those companies have difficulty providing their pre-developed competitive product to the customer when production is moved into a new environment. The new, longer supply chain is unable to deliver the originally intended product (or unable to deliver the product in the time and manner intended) because of a mismatch between supply chain capabilities and supply chain uncertainty.

4.3 Important Considerations in Sourcing

The large issue facing candidates for offshoring is the lack of a fully outlined method for evaluating options. Some companies resort to using private consultation in

order to make the difficult decision at hand. Therefore, this section focuses on the important considerations listed by experienced firms or other contributors that have publicized their work. The overview of these strategic concerns is analyzed to formulate the later-mentioned decision technique.

4.3.1 Asset Risk

One important consideration is the concept of current asset risk versus proposed strategic risks. As previously mentioned, controlling uncertainty per the capabilities of the supply chain is vital to successful production overseas. For example, one of the most common sources of uncertainty in global strategies is the cost of oil. The cost of shipping, whose uncertainty primarily consists of the price of oil in the CBS, makes up a large portion of the total cost of a globally manufactured product. A McKinsey study in 2008 (a poor year in economic terms) estimated that the shipping cost (without tariffs and duties) comprised nearly 10% of the total product cost, a number that had risen from values below 3% in 2000 [27]. While companies would not disagree with the lack of predictability natural to the current oil market, some may not be financially valuating fuel risk (or other future risk) effectively. Dealing with these unknowns in financial terms can be difficult and often requires adjusting predetermined cost of capital rates.

Traditionally, the cost of capital used by a corporation relies on the risk of currently held assets, but understanding a global option for strategy should require more detail for quantifying uncertainty. When managers deal with intricate evaluations steps like risk adjustment, companies can have a better picture of how risk in a specific market can manifest as uncertainty in a particular cost – and can henceforth understand that risk's *relationship* on the bottom-line value of a strategy.

4.3.2 Responsiveness and Efficiency

The incorporation of risk into strategy valuation, though, does not determine the success of the firm – valuation is only a measurement tool that helps in the decision process. Other design variables require adjustment in order to match the strategy best suited for a company. The underlying choice that an organization makes when globally sourced is to be responsive (i.e., to respond quickly to market changes and customer demands) or to be efficient (i.e., to value cost-effectiveness to pursue competitive pricing). The tradeoff between these two characteristics defines the overall supply chain strategy [11].

One such example of this tradeoff is the attention to freight and inventory costs. These two categories are a large part of defining the level of efficiency for an international company. Many firms have opted to use regional distribution in order to aggregate shipping (and, consequently, reduce transit costs); unfortunately, the effort to reach higher levels of efficiency through increased inventory is difficult to balance due to augmented safety stock levels and increased uncertainty at the global level [28]. For this consideration, the price of oil and the price of inventorying finished goods critically affect the cost-effectiveness of the sourcing strategy.

Another important design consideration is the balance of production costs and freight costs. Contrary to the previously mentioned consideration, flexible production capacity can combat the uncertainty associated with the global markets. However, flexibility damages the bottom-line cost savings gleaned from global sourcing. Constant and dedicated manufacturing[42] strategies offer the best avenue for leveraging economies of scale; meanwhile, flexible manufacturing is able to adapt to more customer and

[42] *Dedicated Manufacturing* is a production strategy with minimized *production flexibility* in order to exploit economies of scale.

environmental shifts through not only variable capacity but also with the ability to produce different types of products at the same facility [28]. Thus, companies have to decide whether the value of flexibility, a supply chain feature that lessens the blow of market volatility, is worth the price of reducing cheap manufacturing structures that fail during major economic fluctuations.

Though flexible production is an effective method for introducing supply chain responsiveness, it is not the only choice. Dual sourcing[43] of suppliers is an acceptable option for companies concerned with supply chain disruption. This technique benefits a company by diversifying the risk of a supply chain disruption among two different suppliers [19]. However, the value of diversification has to be balanced with the need to foster more supplier relationships [29]. Dual sourcing may not be a large issue to this concept, but managers should consider the difficulty that may occur in building trustworthy relationships with foreign suppliers.

In addition to adding flexibility to the manufacturing function within the supply chain, companies are also opting at locating closer to the customer. Sourcing production near the customer aids in ensuring lead times, fosters higher levels of customer service, and offers a lower transportation cost for finished goods [28]. The attention to the sourcing strategy from a responsiveness and efficiency standpoint gives light to another difficult issue. In the evaluation of different strategies, flexibility or other responsiveness characteristics must be valued in some manner in order to equate them with cost figures.

[43] Though not discussed in detail here, dual sourcing can apply to the sourcing of manufacturing. Some companies may wish to source the static portion of their demand overseas (for the sake of cost savings) while maintaining flexible, domestic production for the dynamic portion of demand (i.e., mulishoring) [19]. The discussion of dual sourcing in this section, however, deals with the phenomena from the perspective of material and component suppliers versus manufacturing service providers.

Valuating a strategy based on cost without supply chain flexibility[44] gives no information about the strategy's effectiveness in dealing with supply chain volatility. Therefore, the decision process needs to accommodate methods for valuing supply chain flexibility.

With a quick survey of some factors that determine the goal of the supply chain strategy (and, consequently, the sourcing strategy), the discussion of the difficulty in global sourcing is clear. Herein lies the paradox of offshoring: this strategy attempts to reach a higher level of supply chain efficiency, yet a commonly recommended solution[45] for reducing the burden of unforeseen costs is to increase supply chain flexibility (i.e., responsiveness). Hence, the successful deployment of offshoring is not dependent on the effort of the company to increase efficiency; the successful firm traditionally improves both responsiveness and efficiency (illustrated in Figure 4.3).

[44] *Supply Chain Flexibility* refers to the ability of a company to adjust to volatile shifts in variables associated with the supply chain. The variables include customer demand, fuel prices, supplier failure rates, etc. [16]

[45] See [16] and [28] for detailed recommendations of increased flexibility.

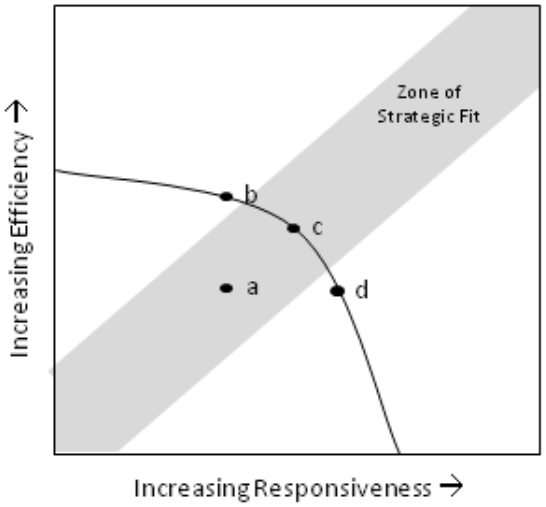

Figure 4.3 The Responsiveness-Efficiency Frontier

Note: The increase in responsiveness and efficiency illustrated by the move from points "a" to "c" stems from discussion of strategic fit in Chopra's and Meindl's *Supply Chain Management* [11].

In the Responsiveness-Efficiency Frontier, point "a" represents a company that is considering different strategic options in order to increase corporate worth. A move from point "a" to point "b" entails that the company has cut costs, such as in an offshoring scenario, but is now outside of strategic fit; though this choice saves money, this company would have trouble meeting quality standards, lead time guarantees, or product launch deadlines. Conversely, a move from point "a" to point "d" illustrates a corporation choosing a strategy that does not save on costs but is better suited for uncertainty. This firm, though, would suffer from costs much too large for competitive environments. The final improvement strategy, a move from "a" to "c," displays the best option because costs are reduced, uncertainty in the supply chain is managed, and the overall strategic fit is maintained.

4.3.3 Product Characteristics

With all of the discussion currently focused on different supply chain characteristics, a holistic perspective requires the investigation of a few other major components embedded in the decision process. Product characteristics should be major factors in the evaluation of strategy. The type of manufactured goods provided by the firm governs all inventory costs, freight costs, price elasticity, and critical supplier dependency; in addition, customer demographics[46] play a major role in forecasting the demand. Figure 4.4, provided by a McKinsey study, illustrates the changes from 2005 to 2008 in the technology manufacturing sector; due to increased logistical costs from product weight, types of products that once were suited for overseas or continental foreign production became good candidates for reshoring or nearshoring[47] [27].

[46] HCCS is an example of a sourcing strategy that critically depends of the customer demographic. This choice relies on customers valuing higher product and service quality over lower costs to maintain a market share [30].

[47] *Nearshoring* is an organization's use of a foreign but continental region's labor resources to serve customers in a domestic setting. Nearshoring may entail lengthening a supply chain by leaving domestic operation (i.e., cheapening labor rates) or may entail shortening a supply chain through abandoning offshored operations (i.e., leaning supply chain). Most commonly, nearshoring balances the geographical length of a supply chain with labor compensation costs. In addition, a company's choice to pursue nearshored operations but still maintain its current intercontinental operations is considered a nearshoring strategy. [16]

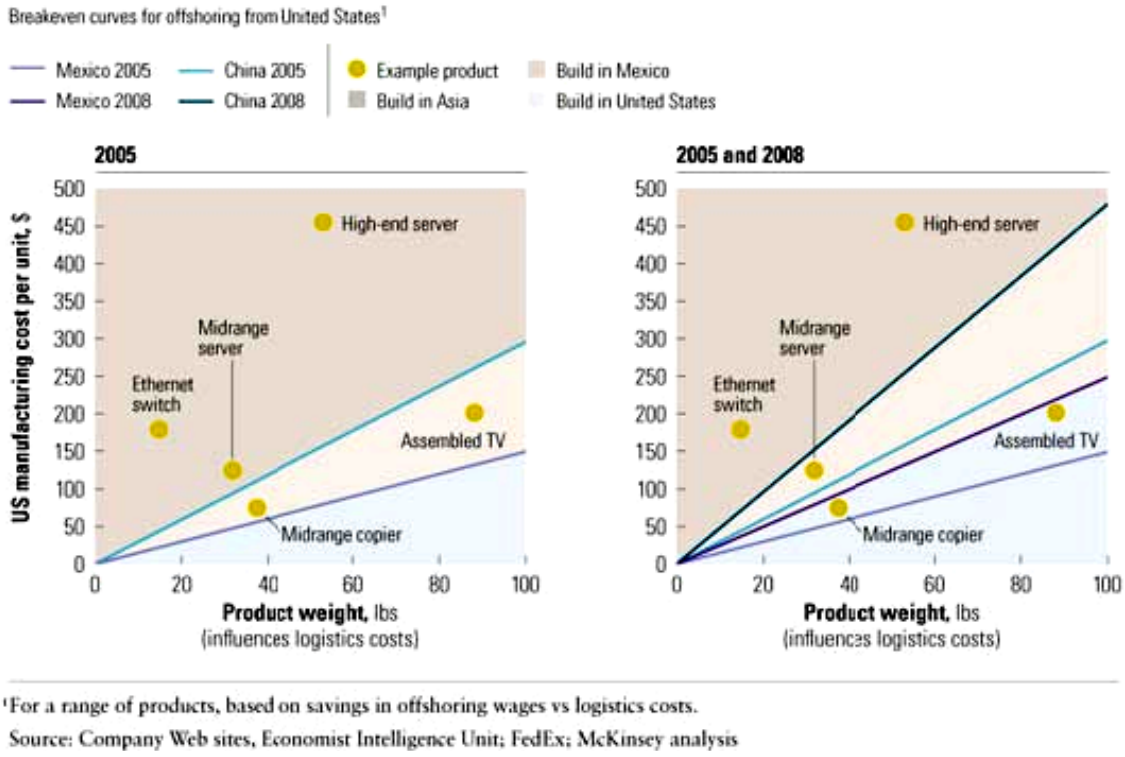

Figure 4.4 The Effect of Product Weight on Sourcing [27]

Note: The figure displays that from 2005 to 2008, midrange copiers and assembled televisions became suited for U.S production in place previously favored nearshoring options. Furthermore, offshored produced midrange servers were more cheaply produced in Mexico.

Other important product characteristics warranting scrutiny are intellectual property dependency, finished product value, and the ratio of labor value to material value intrinsic to a product. All of these considerations could have a severe impact on the decision to source production.

4.3.4 Site Selection

The final discussion point focuses on the capabilities of different geographies. Not only should suppliers be considered in site selection but also the willingness for supply chain collaboration and the ability of the labor market should have weight in the

decision. As mentioned in Chapter II, productivity in the United States is far ahead of most foreign countries due to the prevalence of quality production programs such as Lean and Six Sigma. However, the culture of embracing improvement strategies can extend beyond the plant floor; supplier collaboration and even internal functional collaboration, such as design for manufacture[48], needs attention in the final assessment of strategic fit [4]. Companies that value efficient product lifecycle management and accelerated product development may not be good candidates for large, globally sourced manufacturing centers.

4.4 A New Approach to Selecting a Sourcing Strategy

Because the primary goal of this study is to provide a holistic approach to selecting a production source, the new decision methodology is based not only on the sourcing strategy but also on the strategic fit. Since the competitive strategy governs the overall experience of the customer, it cannot be neglected in the decision process; moreover, the three primary strategies (product development, supply chain, and marketing and sales) all make the competitive strategy possible [11]. Primary design variables define the different strategic options and the different ways each component of a choice supports the overall competiveness of the firm. Design variables are essentially controls; they include, but are not limited to, flexibility options, such as dedicated manufacturing, cycle service levels, and production capacity; product options, such as intellectual property reliance, product lifecycle management, and modularity design; and

[48] *Design for Manufacture and Assembly* (DFMA) is a product and operations strategy that emphasizes major collaboration between the production and design functions of a company in order to ease manufacturing complexities while still maintaining overall product design goals. Lower costs and higher product value potentially result from DFMA. [4]

customer strategies, such as high service quality, low cost, and diversified product offering.

The magnitude of the sourcing decision would not normally include consideration of some these variables, but companies that successfully manage global production are able balance these smaller choices with strategic fit. These companies perhaps have a better understanding of the relationships among internal enterprise components. In addition, they probably focus on environmental requirements during the design of the sourcing strategy. Sourcing the manufacturing function without accounting for the requirements of the supply chain and the requirements of the competitive strategy is not an option. Sourcing is the primary portion of the supply chain strategy; therefore, selection of options that cannot meet a nonnegotiable aspect of the competitive strategy needs to be penalized in the evaluation process. Decisions about competiveness lead to the best conclusion.

4.4.1 The Four Model Approach

The outlined technique involves a four-step approach that deals with design and evaluation. The decision methodology for selecting a strategy consists of four steps:

1. Defining proposed strategic options,
2. Identifying cost relationships according to the CBS,
3. Investigating the prominent risks associated with each strategic choice, and
4. Evaluating the proposed options.

These four steps provide the decision maker with a clear process that describes different stages of problem quantification and evaluation. Furthermore, each step contains a model for encapsulating information and relating them together for a final

evaluation. These four models[49] are the Decision Model, the Cash Flow Model, the Uncertainty Model, and Valuation Model. Another important point about using this method includes the tactical approach to the problem: splitting the work into four model-building steps creates an easily understood division of labor that can be handled by several different specialists [25]. Finally, the four-model approach offers a way to track the favorability of different sourcing strategies included in the same competitive strategies. This concept provides insight into choices that are suboptimal; that is, decision makers may find that a cheap sourcing strategy offers a higher total cost from the corporate-wide competitive strategy perspective.

4.4.2 The Decision Model

The Decision Model represents the different choices at hand for corporate managers. Options include pure sourcing changes, overall competitive strategy changes, and any hybrid of these two previous changes. In order to encapsulate all of the different strategies, decision tree analysis is the best choice[50]. With a time horizon in mind, the different strategic options modeled in a network of branches fully constitute the overall strategy choice. Figure 4.5 displays a spectrum of strategies described by decision trees.

[49] The four model approach used in this study is largely attributed to "Real Asset Valuation: A Back to Basics Approach." Though the methods outlined in the journal article are primarily focused on total corporate valuation, the process used to approach the problem contains a holistic perspective that lends itself well to the global sourcing decision. [25]

[50] The need for decision trees constitutes a portion of the discussion about the "model vision" addressed in Chapter V.

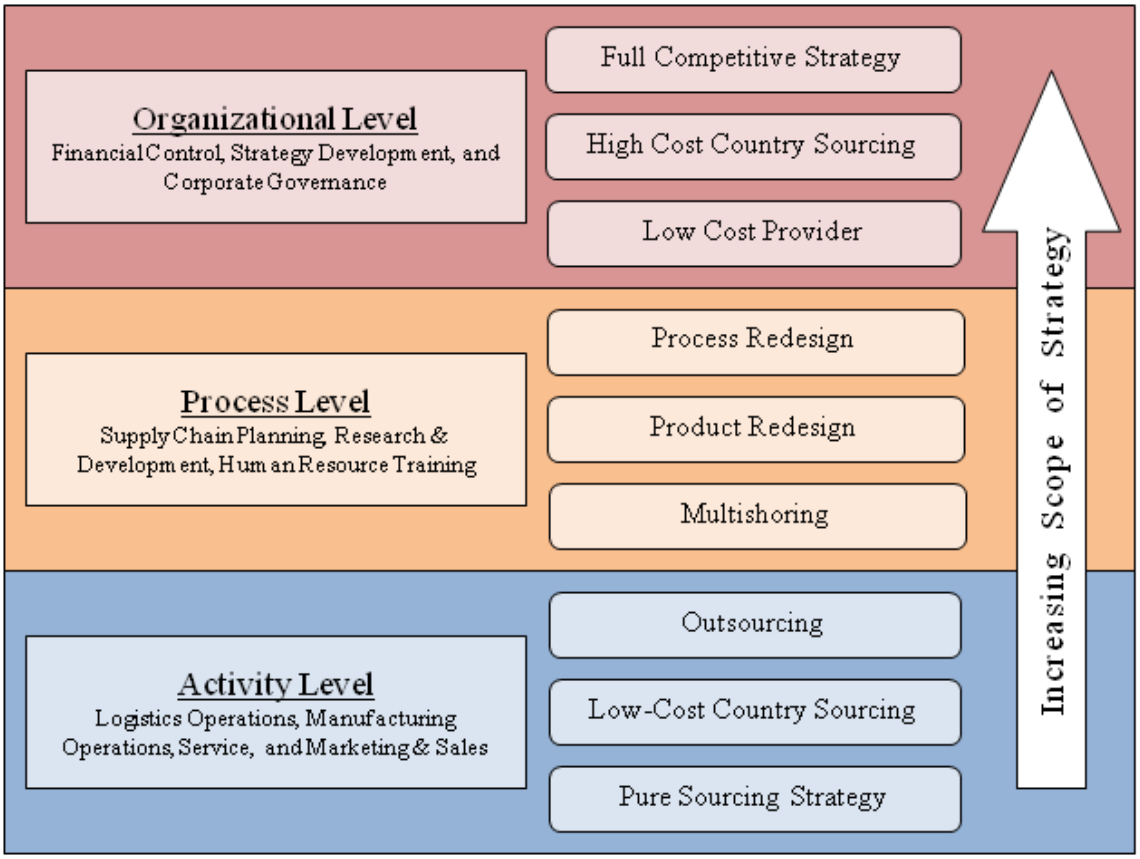

Figure 4.5 Spectrum of Sourcing Strategies

Note: The three levels represented in the diagram include transactional activities at the performance level, to controlling roles at the process level, and long-term, corporate-wide control at the organizational level. The strategies listed on the right affect some levels more than others do; each strategy is coupled with the level of performance most affected. Strategies at the top of the diagram are said to have greater strategic scope than those at the bottom of the diagram. (The organization for this diagram stems from the affinity diagram's supply chain choices, *Supply Chain Management's* discussion of strategic scope, and Harmon's performance framework [11], [20].)

Described in *Business Process Change*, the levels of activity illustrated by Figure 4.5 stem from Harmon's modified version of the performance framework defined by Rummler and Brache [20]. Each type of strategy listed aims to describe the important characteristics of its native level; essentially, strategies located nearer to the top of Figure 4.5 are more closely associated with competitive strategies than those located at the

bottom of the diagram. An interesting result displayed is the location of plain sourcing strategies: they are focused on changing operational characteristics but do not necessarily correlate to long-term organizational goals[51]. This illustration explains the issue of creating disparity between the competitive strategy and the sourcing strategy (i.e., a lack of strategic fit). Also illustrated by Figure 4.5, High Cost Country Sourcing[52], as defined by David Jacoby, deals not only with sourcing issues but also customer markets, quality control, intellectual property development, and supply chain risk aversion [30].

With the many different strategies displayed in the preceding figure, the important differences among these choices require a detailed understanding. The useful method for displaying these differences is via an enterprise map[53]. Enterprise mapping excels at illustrating key differences among strategies because of the process focus natural to the tool. Functional (or "vertical") structure of an organization does not drastically change from one sourcing choice to another; however, the methods of daily operations are often unique for each option. The enterprise diagram employs a divisional[54] (or "horizontal") structure to track the many important facets of a global network; furthermore, the tool includes suppliers and customers as well as external environments. The enterprise diagramming methods aid not only in conceptually illustrating the different strategic

[51] The aim with this comment is not to claim that sourcing strategies are not important but that they must be chosen to support a larger competitive strategy. For instance, low-cost providing may succeed in part through a LCCS strategy.
[52] *High Cost Country Sourcing* (HCCS) is a competitive strategy that emphasizes the use of costly manufacturing in order to guarantee company characteristics other than low cost. The primary goal of HCCS is to provide products with value-added services, complex intellectual property characteristics, and high quality. With these tenants upheld, firms are able to earn higher margins from sales and earn consumer respect from service and quality standards. [10]
[53] The diagramming techniques used represent a modified version of Alan Brache's enterprise diagrams in *How Organizations Work: Taking a Holistic Approach to Enterprise Health* [31].
[54] *Business Divisions* represent hierarchal levels of a company; the Rummler and Brache organizational framework references three levels of business division: organizational, process, and performance levels [20].

options but also in identifying important characteristics in the later mentioned Cash Flow Model.

In terms of globally sourced manufacturing, an enterprise diagram clearly illustrates the large amount of cross-functional relationships within the firm. In addition, traditional views on organizational structure tend to emphasize internal make-up, but the enterprise systems engineering perspective on the matter is concerned with the *entire system* of customer order fulfillment and service. Therefore, environmental aspects, supplier criticality, and customer interactions or responses can be better understood via the enterprise diagram.

The following enterprise diagrams contain visual explanations of some issues within the offshoring problem; the discussion that follows each diagrams references details about each figure.

As displayed in Figure 4.6, the main parts of the enterprise diagram are the three external components (inputs, outputs, and environment) and the internal structure of the firm. The important aspects of the diagram are primarily the relationships among units; an arrow marks a relationship as well as specific information and material exchanges between two business functions. Thus, the diagram displays the business processes that are cross-functional. For the generic insourced, onshored firm outlined by Figure 4.6, manufacturing appears to be a core function that executes large amounts of communication to several units.

Figure 4.6 brings the firm closer to understanding the complex relationships that define the enterprise as a system, per the Giachetti's definition [2]. The external supplier and customer relationship are crucial to understanding the dependencies that a firm has in a particular strategy. While external relationships may entail some of the extra risks that

a strategy includes, Figures 4.7 and 4.8 focus on internal relationships and roles in the enterprise.

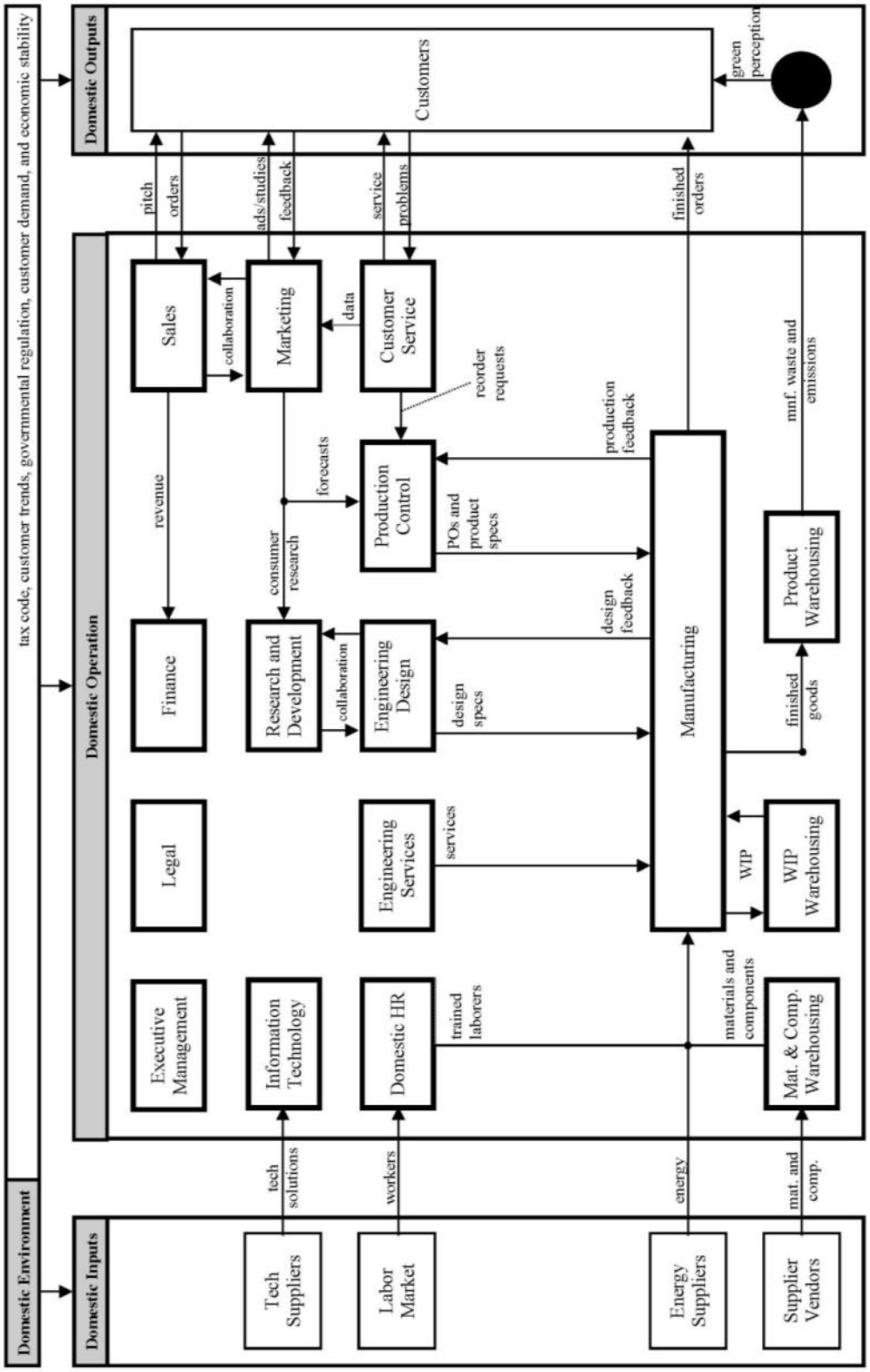

Figure 4.6 Insourced, Onshored Enterprise Diagram

Figure 4.7 highlights the main areas of secondary activities outlined by Porter's Value Chain. These business units enable the key operational roles (e.g., manufacturing) but do not directly affect the value creating steps that a product experiences before being delivered to the customer. The secondary roles are key to controlling and to enabling the primary activities of the firm. The type of communication from the secondary roles to the primary operational functions may be considered "cross-divisional[55]." Cross-divisional communications exhibits the ownership and control expressed by different areas of the firm. The concept of cross-divisional communication resulted from the affinity-diagramming step in Chapter II in which different organizational structures are compared.

[55] *Cross-divisional Communication* is internal company exchanges of information that imply a level of business being enabled and controlled by a higher division.

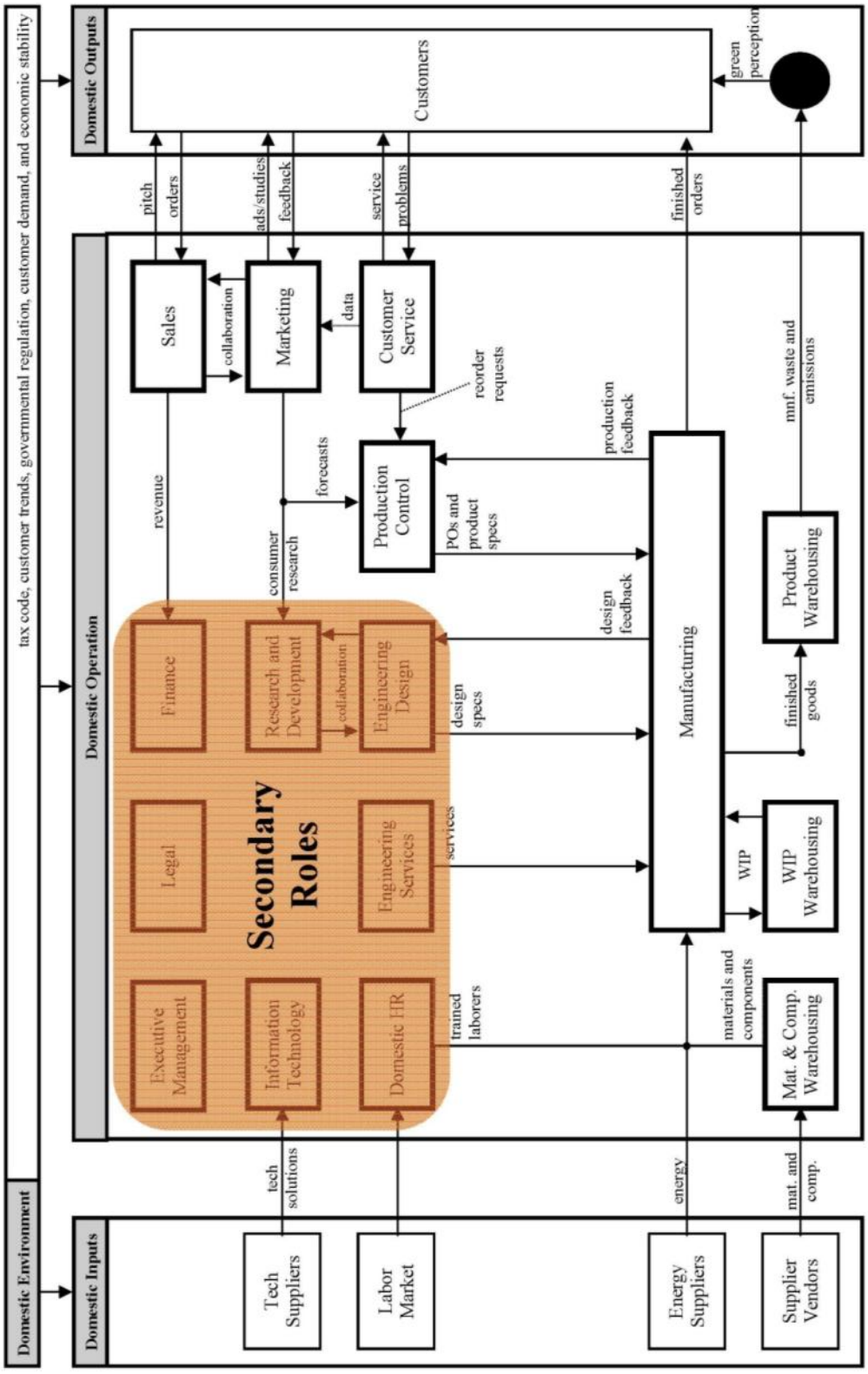

Figure 4.7 Secondary Roles of a Manufacturing Enterprise

Figure 4.8 illustrates the business functions whose jobs focus on technology. Though research and development as well as engineering design are normally considered the primary units that cultivate technology innovation, collaboration among other highlighted roles are vital to solving internal issues and gaining competitive advantages. In addition to the technology innovation core, collaboration may occur among marketing and research and development or design. Companies that are excellent at grooming innovation may benefit from locating some of these highlighted functions near one another.

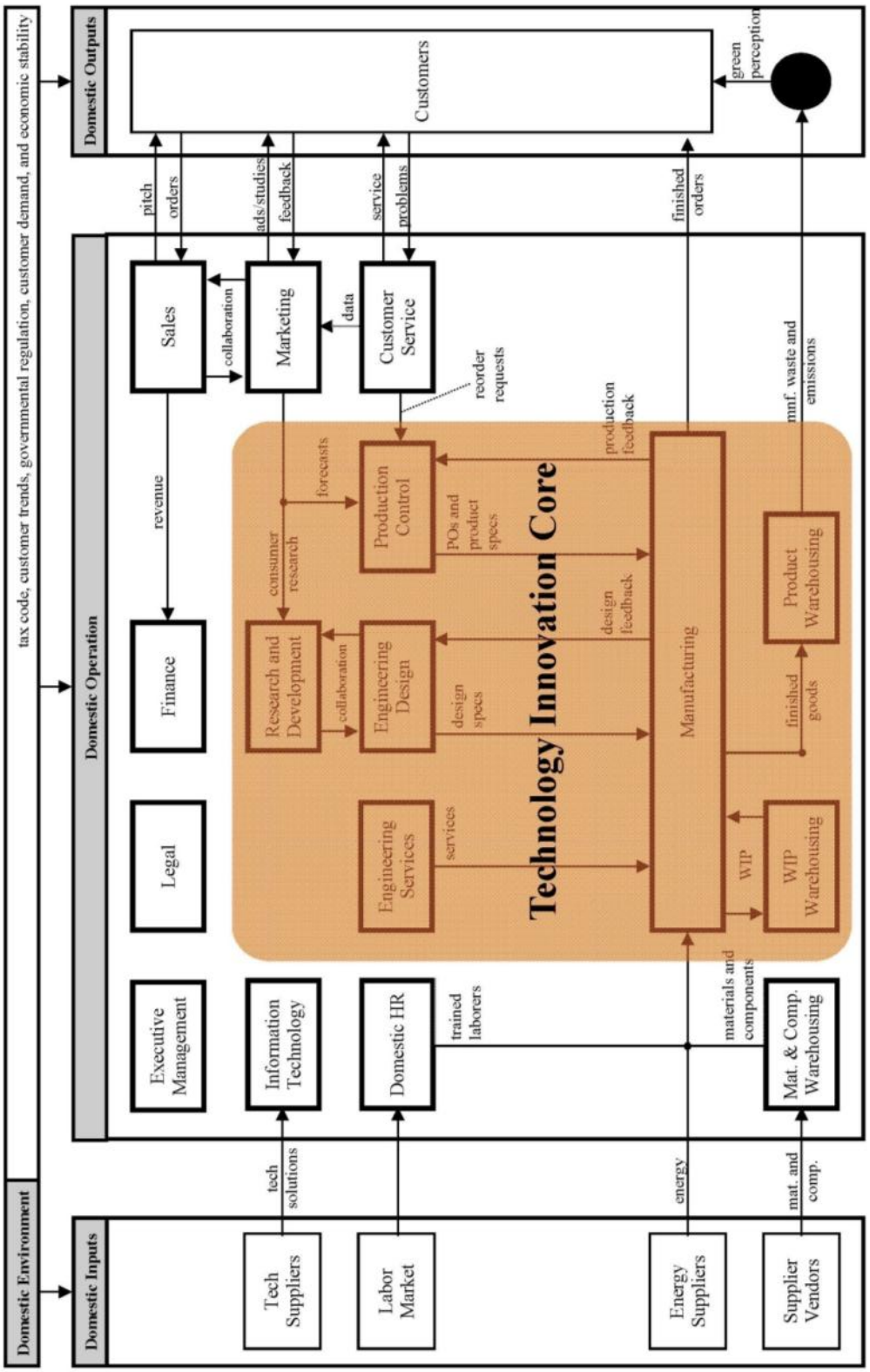

Figure 4.8 Technology Innovation Core of a Manufacturing Enterprise

While the previous three figures focus on a domestic enterprise, Figure 4.9 exhibits a more complex, offshored configuration. In addition to the four major components listed by Figure 4.6, the insourced, offshored enterprise diagram includes foreign inputs, service inputs, foreign outputs, the foreign environment, and the global environment.

First, the new relationships among external units are discussed. Figure 4.9 illustrates the company's reliance on particular suppliers and service providers. Service providers may not normally be included in a domestic enterprise diagram, but offshored business units traditionally require at least shipping processes as a major function for fulfilling customer orders. The two nondomestic environments display the additional risks associated with global sourcing. These risks are not internal to new assets owned by the offshore company, but still reflect risk that needs to be dealt with in later-mentioned valuation steps.

Second, the internal characteristics of the diagrams are discussed. The many relationships that the manufacturing function exhibits now span international waters. In particular, the secondary (controlling) roles in Figure 4.7 are no longer associated with much of the value creating activity in the firm. In addition, the members of the technology innovation core in Figure 4.8 no longer benefit from being located near one another. Furthermore, transfer-pricing transactions are now visible via financial relationships among cross-border functions. Firms may need to investigate both their ability to control operations and to cultivate innovation in the offshore case.

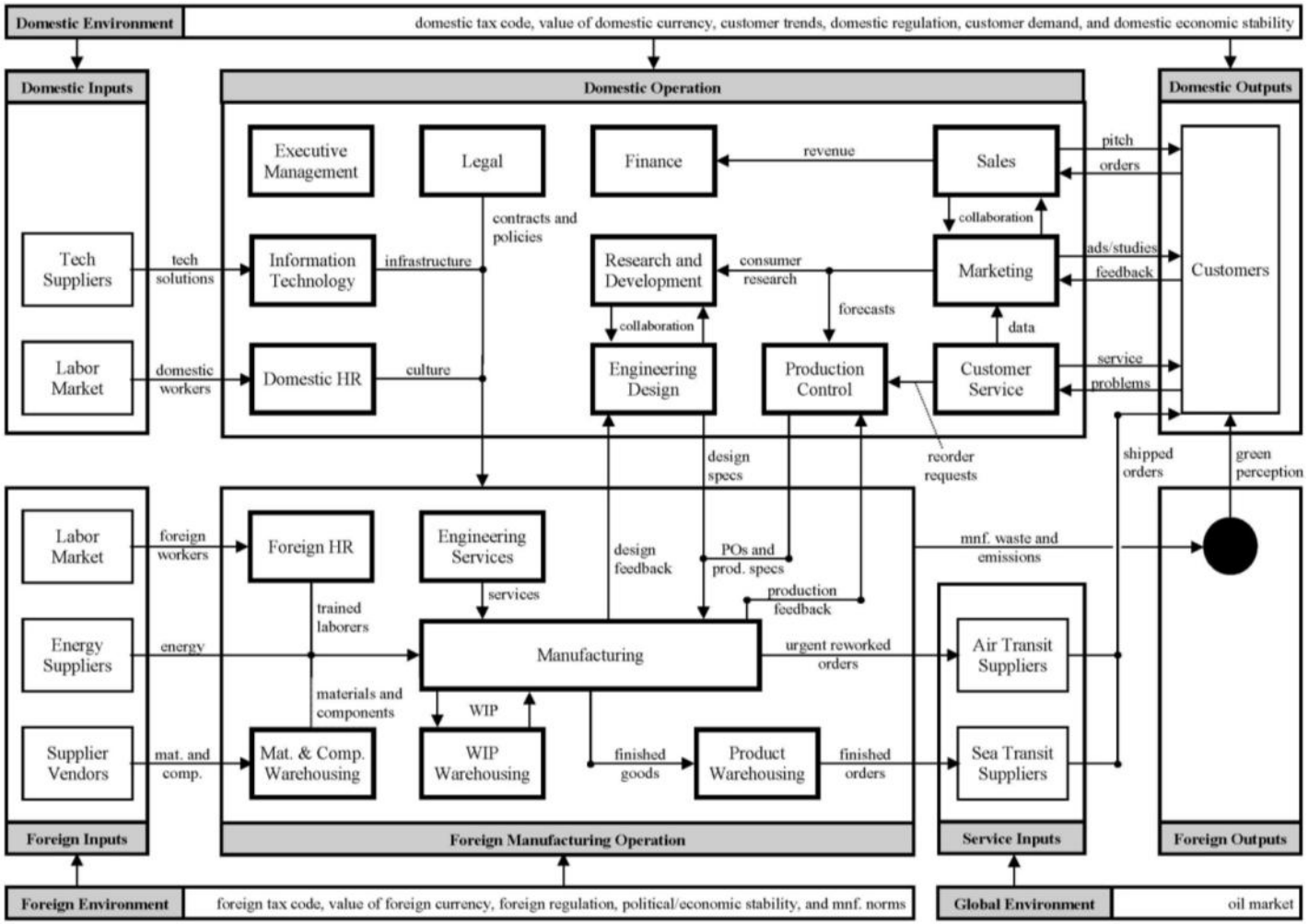

Figure 4.9 Insourced, Offshored Enterprise Diagram

4.4.3 The Cash Flow Model

The next milestone toward reaching the sourcing decision is to construct the Cash Flow Model. As described in Chapter III, the CBS is the main tool used to make up the Cash Flow Model. Most of the aforementioned design variables that determine the distinction among strategies in the Decision Model manifest in this step; thus, the two models are linked together via the control variables [25]. For instance, the choice of a high quality supplier, the cycle service level for an inventory policy, or the time chosen to launch a new product are all examples of control variables in the Decision Model that directly change cash flows in this step. An important note is that the three example variables discussed are not themselves cash flows; as mentioned in the discussion of the CBS, the items used to describe cash flows should deal with fundamental sources of costs and revenues. The emphasis on fundamental variables aids in creating a consistent approach to cost estimation among different alternatives and in determining sources of uncertainty.

In the next chapter, defining the relationships between a cash flow and its sources is a major step toward completing the Cash Flow Model. Emphasizing the systems nature of the enterprise, cash flow are no long dependent on sweeping, top-level projections but are related to several fundamental components of the production sourcing strategy and the market.

4.4.4 The Uncertainty Model

If the values used in the Cash Flow Model are neither control variables nor a constant input, then the figure is an uncertain input. These variables are components indescribable through deterministic means (e.g., fuel costs, demand, lead time, etc.). In

order to incorporate uncertain variables into the Cash Flow Model, the users create an Uncertainty Model for formulating stochastic characterizations. If the risks included in discussion among managers are to be included in a financial valuation (rather than a potential qualitative evaluation), three characteristics of the risks are required:

1. Risky variables must be quantitative,
2. The information about risks must be understood in relationship with time, and
3. The risks should be classified into asset-level[56] or economy-level[57] variables. [25]

The first claim in the above list is a difficult action to take for many companies. Truthfully, some risks are hard to quantify, but if a clear reduction of factors cannot lead to a numerical result, then that variable cannot posses valued uncertainty. The main concern is qualitative model users may doubly or partially account for some risks; that is, a variable should not be characterized stochastically in addition to tampering the final evaluation of a strategic choice based on a component related to that variable.

The second claim in the list is a straightforward requirement: decision makers learn more about uncertain situations as time continues. Thus, some risks may decrease (in valuation penalty) as time continues. Furthermore, the third requirement introduces terminology for categorizing the different types of risk. Asset-level variables relate to internal company issues, such as a technological success or an intellectual property infringement; meanwhile, the economy-level risks are related chiefly to the external environment (e.g., fuel prices and customer demand) [25].

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[56] *Asset-Level Variables* are uncertain input variable within the Cash Flow Model independent of external economic performance. Examples are success of a new R&D technology, the major infringement of an intellectual property, or (insourced) production lead time. [25]

[57] *Economy-Level Variables* are uncertain inputs in the Cash Flow Model that heavily correlate to an overall economic trend. Examples include fuel costs, demand forecasts, and supplier lead times [25].

4.4.5 The Valuation Model

The final step in the decision process is to enter all of the data gleaned from the previous steps into the Valuation Model. Discussion of the Valuation Model is saved for Chapter V because of its relationship with the overall model vision. Since the Valuation Model dictates some of the technical details of all three previous models, the choice of valuation method has a profound effect on the complexity of modeling and the quality of a decision.

CHAPTER V

MODELING THE GLOBAL SOURCING DECISION

5.1 Research Methodology

The goal of Chapter V is to provide a vision for modeling the global sourcing problem; thus, much of the content in this section focuses on the Valuation Model briefly mentioned in the preceding chapter. Reaching the final model vision relies on reviewing the overall components of valuation, analyzing a common valuation method and its shortcomings, and exploring robust styles of valuation. Once each of these topics is discussed, the final step in the study reduces all of the information from these sections into a model vision. In order to emphasize an ESE viewpoint, the procedures required to operate the proposed model architecture is a point of emphasis. In addition to creating the model vision, the research methodology in Chapter V focuses on linking potential model tools to computer-aided engineering resources already available for consumer use.

Again, the overall focus on relationships within the enterprise is relevant to this section of the study. In addition to employing the use of a system dynamics model, the model vision suggests the incorporation of Monte Carlo simulation. While system dynamics simulation addresses the system relationship problem prevalent to global sourcing, the Monte Carlo methods apply well to the many instances of uncertainty. Addressing relationships and variability uphold the ESE perspective stating that the firm and its surroundings comprise many interrelated parts and that the future behavior of those entities is uncertain [2]. For these reasons, simulation procedures under the "Tools"

section of the affinity diagram in Chapter II are the selected means to reach a model vision.

5.2 Overview of Valuation

The usefulness of quantifying all the strategy choices, cash flows, and risky characteristics associated with the sourcing of production is highly dependent on the quality of the Valuation Model. The information gathered in the three previous steps of the decision methodology is meaningless without a mathematically consistent technique to reduce all of the raw information into a financial value. The four primary objectives of the valuation step in the decision process are

1. To offer a financial metric for comparing different strategic choices,
2. To valuate uniformly among several different options,
3. To incorporate issues of process and forecast uncertainty as well as asset risk, and
4. To encapsulate long-term financial performance.

A holistic approach to valuation must uphold these four objectives. Although this list is concise, its application entails the use of methods that take into account several issues that materialize as a result of considering global sourcing options. Moser's TCO Estimator in Chapter III deals these objectives but insufficiently addresses the concept of variability associated with objective three; the TCO Estimator relies on average values for analysis [24]. The reasons for these four points stems from the need to include consistently variability and system interdependency considerations in the model.

First, strategies that are unable to cope with supply chain uncertainty should have a lower financial value than those choices that control uncertainty. In other words, the agility of a manufacturing system, the stability of a supply sourcing strategy, or the

capability to offer pull-side inventory systems represent monetary value. Second, the Valuation Model needs to account for decision flexibility[58]; thus, decision trees, which are discussed below, are likely an efficient method for tracking different decision options that are available within a strategic choice. Third, high inventory costs, large stock out costs, and bulky working capital constraints should deduct from the overall value of a choice. By including these types of considerations, the Valuation Model rewards choices that offer reliable lead times, lean inventory systems, and low working capital requirements. Finally, the phenomenon of exchange rates[59] offers another vital inclusion; the many opportunities for exchange rate effects stems from the many instances of international transfer pricing that may occur in a globally sourced firm. Figure 5.1 summarizes the proposed characteristics of the Valuation Model.

[58] *Decision Flexibility* refers to the amount of future decision options that management may have within a strategy. More future option entails higher decision flexibility.
[59] Appendix B offers a brief description of the issues with exchange rate risk.

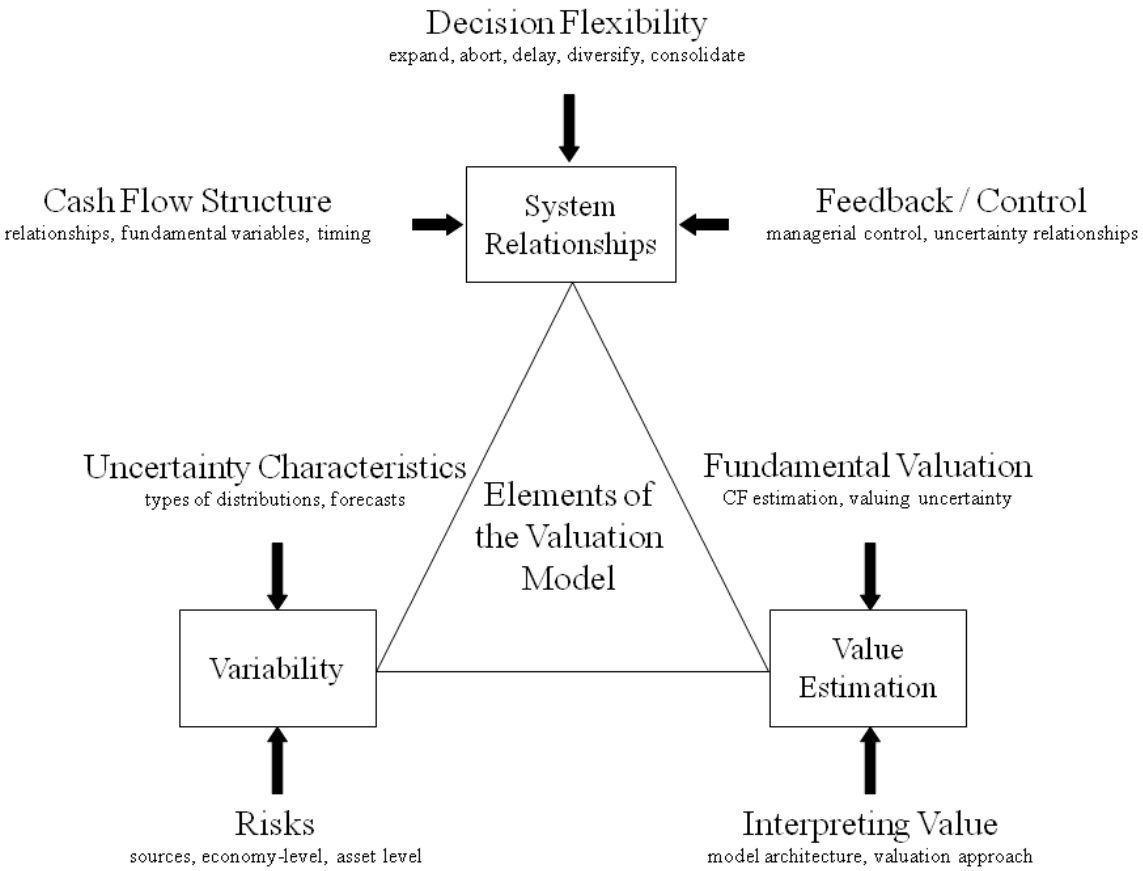

Figure 5.1 The Elements of the Valuation Model

Note: The Valuation Model, which gives financial measure via the three other models mentioned in Chapter IV, consists of three main elements: variability, system relationships, and value estimation. Variability addresses the concerns of uncertainty in the global market. System relationships incorporate the ESE focus on interdependencies in the enterprise [2]. Finally, Value Estimation addresses getting physical values for variables (and interpreting that value based on the model architecture). The basic structure for this diagram (as well as a few elements of content) stems from "An Overview of Using Dynamic Discounted Cash Flow and Real Options to Value and Manage Petroleum Projects" [32].

5.3 Problems with the Current Valuation Approach

The most common method for financial valuation at the organizational level is the Discounted Cash Flow[60] (DCF) Model. The DCF Model, which sees use of net present value as the main performance metric, is generally displayed as

$$E(NPV) = \sum_{t=0}^{n} \frac{E(CF_t)}{(1+i)^t} \tag{5.1}$$

where n is the project life (often in years), $E(CF_t)$ is the expectation of a cash flow in period t, and i is the discount rate [25]. In cases not involving high-risk[61], an analysis includes projecting cash flows and discounting at a rate assigned by a corporate financial team. The discount rate is normally the cost of capital, which represents the time value of money and the risk of a company's current assets. Generally, the majority of risk included in the cost of capital is determined by the capital asset pricing model (CAPM), which relates a corporation's assets to fluctuations in the market at large [33]. Meanwhile, the mean cash flow, located in the numerator of Equation (5.1), is usually a most likely estimate of a value rather than a statistical expectation.

In many situations, the basic DCF Model is a poor method for valuating global projects – rarely do alternatives have the same level of risk and, even then, normally do not have the same level of risk associated with current corporate assets[62]. Thus, financial analysts tend to alter Equation (5.1) in order to deal with its shortcomings. To

[60] *Discounted Cash Flow Model* (DCF Model) is the general valuation approach. In DCF methods, expected levels of cash flow expressed as a present value are calculated via a per-period compounded discount rate. The discount rate reflects the time-value of money as well as corporate asset risk.
[61] In this study, "high-risk" refers to risk that is greater than the risk associated with holding the current assets of a company. Alternatively stated, "high-risk" entails risk not included in the cost of capital discount rate.
[62] Very large companies sourced in several distinct geographies benefit from global risk diversification. The methods outlined in Chapter V assume that the firm lacks diversification in geographically correlated risk. Most small and medium size manufacturers, as well as some large manufacturers, lack diversification. See [15] for discussion of risk aversion ideals based on international diversification.

incorporate risk, two general options are available: characterizing the cash flows in the numerator as random variables or augmenting the discount rate in the denominator. Since the former option tends to be more tedious than the latter, most industry examples of high-risk evaluation favor changing the discount rate to a larger value [34].

Though its easy application makes the risk-adjusted discount factor[63] (RADR) an attractive choice, the use of a RADR generally has a major setback: long-term cash flows may be overly penalized due to the exponential nature of the denominator (i.e., the DCF Model assumes a compounded discount factor). Moreover, many risks are biased toward a negative result; however, using a mode cash flow numerator with an RADR denominator in Equation (1) neglects the large probability of negative risk occurrence and overlooks a gradually increasing corporate learning curve for dealing with that specific risk well into the future [15]. Hence, the use of an RADR does not constitute a robust valuation model component for global sourcing. In addition to these risk inclusion issues, decision options also require discussion as a shortcoming of the DCF Model.

Decision tree analysis (DTA) is traditionally thought to deal with concerns of managerial flexibility that arise during the execution of a valuation; however, the DCF Model used in DTA normally is not suited to deal with real options. The real options perspective emphasizes understanding the different alternatives within a strategy based on choices to expand or to contract operations, to consolidate or to diversify operational characteristics, and to expand or to contract a project life. These choices within a strategy are contingent on market conditions and internal company performance;

[63] *Risk-adjusted Discount Rate* (RADR) is a discount rate used in the *DCF Model* that has been augmented to account for risks beyond those encompassed by a firm's cost of capital. RADRs assume that risks higher than cost of capital values should compound per period similar to time-value of money. [34]

practitioners of the DCF Model tend to leave out long-term real options (or correct risk adjustment factors) that may exists in the event of positive or negative performance [35].

5.4 Preferred Valuation Techniques

Since the DCF Model illustrates several undesirable characteristics relevant to volatile and complex global environments, other methods of valuation must be explored. In particular, the approach needs to encompass the decision flexibility that is inherent to global sourcing and needs to include a balanced and holistic approach for uncertainty quantification. Two methods, Real Options Analysis and Market-based Valuation, are surveyed in this section. These techniques better incorporate real world affects of risks and managerial reactions to those risks than the DCF Model.

Real Options Analysis[64] (ROA) is an alternative, dynamic approach to the static DCF Model. In ROA, several strategy-altering events are considered to be possible at different points within a decision tree; this type of event entails that the firm has a choice of one or more "real options" based on market or firm performance conditions [35]. The strength of ROA is its ability to include decision flexibility into the financial valuation. Within a traditional DCF analysis, decision flexibility is difficult to assign true value and is rarely included; moreover, the tendency to use a constant discount factor does not reflect conditional changes that may prompt a manager to exercise a real option during certain times. A study focused on the financial decision team of the Boeing Company, which created its own ROA method for valuating different strategies, states, "The advantage of the real options approach, then, is its ability to take the wide range of

[64] *Real Options Analysis* (ROA) is a corporate valuation technique designed to value decision flexibility. A real option represents a future decision that is based on internal or external factors that have different chances of occurring. Common real options include opportunities to expand or to contract operations, to delay or to accept project initiation, or to diversify or to consolidate production characteristics. ROA is a component of the general *market-based valuation* approach. [35]

'strategic intelligence' produced by the scenario discussion and translate it into a business plan with flexibility and critical decision points" [36]. As explained by this description, the practitioners of ROA benefit not only from assigning an accurate value to flexibility but also from the discussion required to set up the decision tree. Essentially, managers are inclined to make a robust decision model when executing the initial steps of ROA.

Although ROA[65] has some major benefits to offer the global sourcing decision, it also possesses a few characteristics that are less desirable. The consistency of dealing with risks within ROA sometimes undefined by general procedures, and most detailed procedures for analysis do a poor job of quantitatively relating cash flows to market or company performance. Market-based Valuation[66] (MBV) is a more general and rigorous approach of connecting risk drivers to uncertainty in a cash flow. The main tenant of MBV is that internal and external sources of uncertainty should clearly define possible real options in the decision tree. In MBV, a financial team executes the following procedure:

1. Each cash flow is qualitatively evaluated to determine its risk drivers,
2. Market relationships are quantifiably defined through a cash flow's functional relationship to state variables[67],
3. Different possible states of the market and company performance are defined with assigned state variable values,

[65] ROA is a type of Market-based Valuation. However, the general term "market-based valuation" as used in this study entails a detailed procedure discussed in the following paragraphs. (Terminology among several sources that discuss this technique is inconsistent.)
[66] *Market-based Valuation* (MBV) is a corporate valuation technique that relates market variables to internal company cash flows. In addition to dealing with market sources of risks, MBV appropriately addresses decision flexibility in similar fashion to *Real Options Analysis*. [25]
[67] *State Variables* define the market and company conditions in a *market-based valuation* model. State variables provide feedback that affects expected financial performance for a company. State variables can be a*sset-level variables* (internal to the firm) or *economy-level variables* (external to the firm). [25]

4. All expected cash flows are "state priced" according to state variable conditions,
5. All cash flows are discounted to the present time at the same time-value discount rate [25].

The clear difference between ROA and MBV is the tedious inclusion of state pricing in steps 3 and 4. At the onset of an analysis, decision makers must determine different company parameters, market prices, or security indexes that will possess a functional relationship with the amount of cash flow from a particular source. Though state pricing definitively relates a real cash flow to external and internal risk drivers (i.e., economy-level and asset-level variables), its application is laborious when compared with the DCF Model or even basic ROA procedures.

Regardless of the choice between these two methods, the concepts for ROA and MBV allow companies to avoid the use of the RADR approach that is used with the DCF Model. Instead, both rely on random variable distributions in order to quantify the uncertainty in cash flows caused by different enterprise relationships.

5.5 A Model Vision

The characteristics of MBV and ROA are leveraged in order to propose a model architecture for future use in global sourcing decisions. Though these models relate uncertain variables to cash flows and offer several opportunities to exercise real options in a decision, the model vision also recognizes that ROA and MBV methods can sometimes be difficult to apply and unrealistic for certain companies. Therefore, the following section describes some steps that can be taken to simplify application.

5.5.1 The Decision Model

As described in Chapter IV, The Decision Model is the first step to be executed in the decision process. A complete decision tree needs to be constructed; it should include different real options at particular times. Having enterprise diagrams available for each strategic choice aid in the construction of decision tree as well as in the later steps described. The conversations elicited in this step represent the starting point for reaching a decision. Using the real options perspective reflects emergent thinking native to the ESE approach. The Decision Model should be considered the most important step for upper level management and financial analyst collaboration. As shown by later steps, the framework for decisions discussed at this point is vital to the overall valuation approach taken.

5.5.2 The Cash Flow Model

At the completion of the Decision Model, financial analysts should begin to construct the Cash Flow Model. The basic cash flow structure, represented by the CBS, needs to be defined in this step. Cash flows should be defined as best as possible according to the requirements of next model step. As long as risks clearly relate to cash flows in the Uncertainty Model, the elaboration of the CBS is acceptable. However, users are cautioned that removing too much fundamental variable focus may render this valuation method useless. As described by Equation (5.2), the overall net cash flow for a period, NCF_t, can now be defined as a function of many sources of cash flow, x_k.

$$NCF_t = f(x_1, x_2, \ldots x_q) \tag{5.2}$$

5.5.3 The Uncertainty Model

Now that the net cash flow has been defined for each period in the decision tree, uncertainty needs to be incorporated into the model. As previously mentioned, the use of RADR approaches is considered a poor option, so random variable characterizations constitute the Uncertainty Model. Each uncertain source of cash flow needs to be given a random variable characterization. In order to accomplish this task, different scenarios that represent the possible real options that could be exercised in the Decision Model need to be defined more clearly. Therefore, different state variables are employed to represent different conditions that may occur during the life of the project. State variables may include economy-level variables (e.g., GDP) or asset-level variables (e.g., an internal research and development breakthrough) [25]. In order to keep the model from becoming too complex, the financial team needs to ensure that they choose the least amount of state variables[68] possible to define the Uncertainty Model.

Once analysts have chosen the state variables, the different possible combinations of state variable values needs to be discussed. A unique vector of several state variables represents a decision "state" (e.g., state 1 may be set as a GDP level *a* and a price of oil *b*). These states should essentially define the different conditions in the Decision Model that prompt management to exercise a particular real option. During this step, the probability of a state occurring also requires quantification. Now that different states and their respective probabilities have been defined, risk is ready to be quantified. A source

[68] A suggestion for American companies for state variable choices is US GDP, a foreign GDP, and the price of oil. US GDP relates highly to the performance of the domestic economy and, therefore, the level of domestic supply prices, the strength of customer demand, and other sources of fundamental cash flows. Meanwhile, the foreign GDP correlates to foreign labor rates, supply prices, etc. Finally, the price of oil encapsulates the issue of global fuel risk into the Uncertainty Model; including this price as a state variable would give insight into a strategy's reliance on low oil price volatility.

of cash flow is defined as a random variable dependent on the state[69]. Thus, analysts give each uncertainty x_k a probability distribution for each state, s. (The number of random variable distributions that must be generated is the number of states, *m*, times the number of inputs, *k*. For this reason, the amount of state variables and corresponding state vectors should be kept to a minimum.) Now the net cash flow for a period and state, NCF_{ts}, is defined as a combination of several random variables.

$$NCF_{ts} = f_s(x_1, x_2, \ldots x_n) \tag{5.3}$$

Figure 5.2 summarizes the state pricing procedure outlined in this section. This method ensure that the Uncertainty Model account for risk at the source.

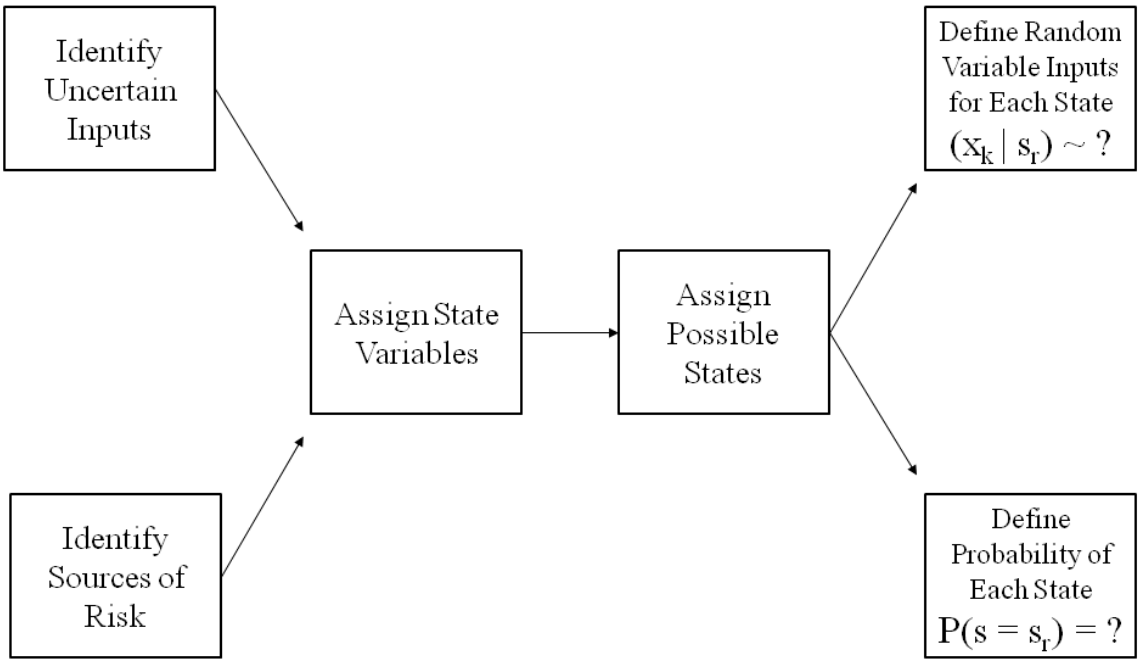

Figure 5.2 State Pricing Procedure

[69] Since the company may wish to consider its ability to adapt in dealing with uncertainty as it learns about the global environment, financial analysts may wish to index the distributions of fundamental cash flow sources not only against different states but also against time.

5.5.4 The Valuation Model

The final step is to construct the Valuation Model. The simplest metric for valuation is the expected net present value, *E(NPV)*, of the strategy in question. The Valuation Model, then, is

$$E(NPV) = \sum_{t=0}^{n} \sum_{s=1}^{m} \frac{p_s * E(NCF_{ts})}{(1 + r_f)^t} \tag{5.4}$$

where $E(NCF_{ts})$ is the mean of a net cash flow distribution for a state *s* at time *t*, p_s is the probability of a state, *m* is the number of total states, *n* is number of time periods, and r_f is the risk free rate set by the company.

Though Equation (5.4) represents a similar approach to the DCF Model listed by Equation (5.1), the usefulness of the mean net present value may be deceiving. The *distribution geometry* of the net present value remains undefined after using Equation (5.4) but may be highly relevant. The valuation of several strategies without understanding the distribution of results could lead to the choice of a highly unstable strategy that has a probable chance of less that desired results. Some analysts may choose to find the variance associated with the net present value of a strategic choice; however, the mathematical formulation of that value is complex and based on Taylor Series estimation. Therefore, simulation becomes a viable option to characterize the overall probability distribution of the net present value.

5.5.5 Simulating the Four Model Approach

Risk simulation in the financial arena usually focuses on Monte Carlo methods, which rely on repeatedly sampling statistical distributions. Though Monte Carlo simulation exhibits the ability to display the distribution of a critical performance metric

rather than just the average or variance, its application to a system similar to the one described above also requires an additional perspective – system dynamics. System dynamics, as defined by its founder Jay Forrester, is "study of information-feedback characteristics of industrial activity to show how organizational structure, amplification (in policies) and time delays (in decisions and actions) interact to influence the success of the enterprise" [37].

Giachetti claims that systems dynamics "highlights the need to better grasp the complex interrelationships of cause and effect, to understand feedback, and to understand nonlinear systems responses." The state pricing procedure described by Equation (5.3) represents a complex feedback system. By constructing a system dynamics model of a global production strategy, the users would be able to link external and internal performance measures to the many different components of bottom-line cost. These measures, which are the state variables mentioned above, offer a means of feedback both for risk manifestation (i.e., *conditional* probability distributions) and managerial control to risk (i.e., *conditional* real options). By incorporating the strength of random variable sampling methods used in Monte Carlo simulation with system dynamics thinking, users are able to characterize decision and cash flow structures, feedback control, and uncertain variables in a methodical approach. Furthermore, the output options offered by most basic system dynamic simulation software packages are numerous; system sensitivity to particular policy or value changes is easier to track in system dynamic simulation than in other analytical approaches.

Even more, software packages may provide an acceptable level of graphical interface to keep nontechnical managers involved with modeling. System dynamics simulation software such as VenSim or iThink can aid in creating the cash flow structure with the use of

its graphical user interface diagramming and automatic equation generators [37]. Giachetti says that both of these software packages feature output graphs to track performance of overall system metrics or component metrics over time [2]. Figure 5.3 describes the proposed system dynamics model.

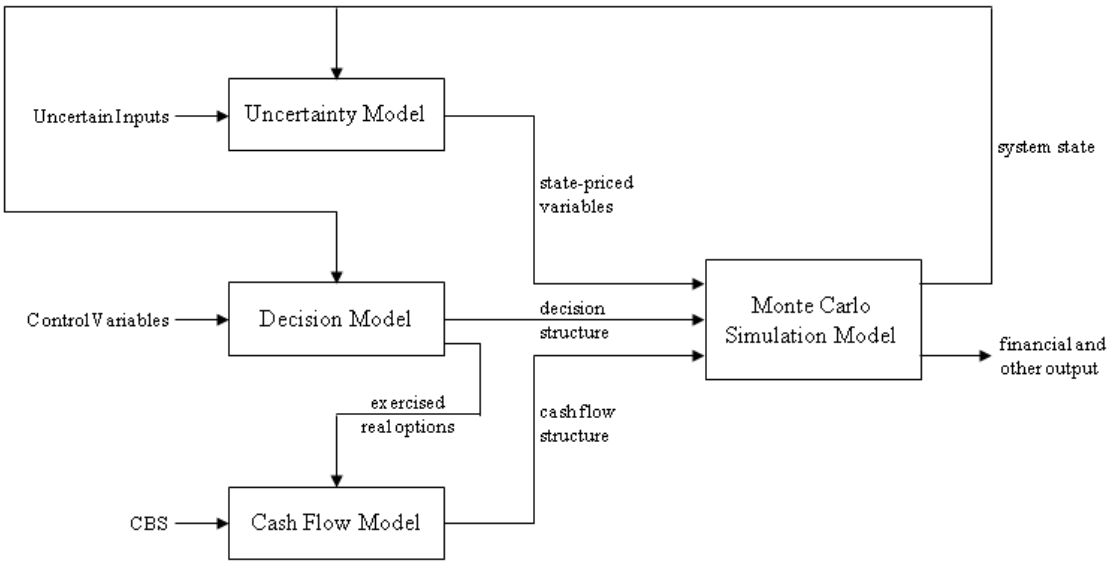

Figure 5.3 System Dynamics Simulation of the Four-Model Approach

Note: In the diagram, the Uncertainty Model, the Decision Model, and the Cash flow model feed information to the Monte Carlo Valuation Model. At certain time periods, the current Monte Carlo results can be used to introduce feedback into the previous models. Furthermore, real option feedback can be adjusted from the Decision Model to the Cash Flow Model. This method differs from the TCO Estimator in its inclusion of variability (through the Uncertainty Model with Monte Carlo simulation), decision flexibility (through real options feedback), and enterprise interrelationships (though system dynamic modeling).

5.6 A Brief Survey of Model Components and Methods

The statistical simulation procedure (i.e., the model vision) outlined in the preceding section contains many smaller steps that are not detailed in this study; however, a list of methods, including options that are not used in the system dynamics approach, are given in the following table.

Table 5.1 Potential Components of Model

Component	Details	Pros	Cons
Discounted Cash Flow (DCF) Model [32]	The DCF Model is the traditional financial approach to valuating corporate investments via Net Present Value. The cost of capital is used to discount cash flows for time and asset risk.	Easy to apply, traditional form of valuation, cost of capital readily available from most corporate financial departments	Does not account fully for decision flexibility, does not deal with time-varying risks, corporate discount rate may not reflect risk in global investments
Market-based Valuation (MBV) [25]	MBV connects important market and corporate variables to the potential inflow and outflows of cash that a company may experience. MBV makes use of detailed state pricing models.	Robust method for dealing with all types of risks, separates risk from discount factor	Difficult to apply, requires understanding of statistical modeling, requires managerial and analyst collaboration, requires large amounts of financial market study
Real Options Analysis (ROA) [35]	ROA makes use of decision tree analysis to value the decision flexibility that a manager may have at a future time.	Robust method for dealing with most risks, emphasizes the value of decision flexibility	Difficult to apply, different procedures for analysis, may offer too much “top-down” focus on risk

Table 5.1 Continued

Monte Carlo Simulation [38]	Monte Carlo Simulation is iterative sampling of statistical distributions used to discover the distribution geometry of a combination of several random variables.	Allows users to view geometry of output distributions, easily applied to a spreadsheet	Lacks dynamic feedback features
System Dynamics Simulation [2]	System Dynamics Simulation is a numerical approach to quantifying the sensitivity of relationships among several components in a system. The approach makes use of differential equations in order to track output responses to user and feedback inputs.	Software graphical interfaces, easy to incorporate feedback properties, quantifies decision policies to system logic, relates system components both mathematically and visually, can make use of Monte Carlo methods	Requires the treatment of model variables as continuous; requires software
Analytical E-V Analysis [38]	E-V (Expectancy-Variance) analysis allows users to evaluate different investment options based on the mean and variance of a choice. In some cases, the largest root sum square of mean and variance is the best choice.	Universal metrics, graphically displayed via E-V frontier	Requires the modification of DCF model for risk-included valuation; analytical variance cannot be precisely found; formulas for variance are beyond the scope of most financial teams' experience

Table 5.1 Continued

Rate-adjusted Discount Rate (RADR) [33]	RADRs are an augmented version of the corporate discount rate. Different project betas[70] are used to adjust the regular cost of capital.	Easy to adjust discount rate, easy to apply to DCF Model	Assumes compounding risk, focuses on systematic risk versus negatively biased risk, RADR values are conditional to level of global risk diversification[71]
State Pricing [25]	State pricing is an approach of valuing an uncertain cash flow or component of cash flow based on external market and internal company conditions.	Mathematically consistent approach to incorporating risk, deals with risk at source	Requires large amounts of work, individual sources of risk must be identified and accurately related to system
Analytical Hierarchy Processing (AHP) [40]	AHP is a qualitative approach to evaluating several options based on user-identified criteria in a decision. By answering a questionnaire, managers can rank strategy alternatives.	Easy to apply, does not require quantitative characterization of risk, the mathematical formulation for AHP is easily administered to spread sheet software	Based on managerial inclinations versus actual data, usually relates a partially risk-adjusted cost with qualitative rankings (may lead double or partial inclusion of risk), results do not offer a expected value but instead a ranking, all rankings are based on original choice of critical criteria (which may or may not encapsulate all issues or correlate among issues)

[70] The traditional capital asset pricing model calculates the cost of equity based on a risk-free rate (e.g., a current T-bill rate), an estimated risk of the market, and a sensitivity of equity to the market. Beta numerically represents this asset to market sensitivity. Normally, cost of equity values calculated using CAPM include most of the risk associated with the weighted average cost of capital (though borrowing default risk can be included in the cost of debt). [39]

[71] *Global Risk Diversification* entails that a large company has many global investments in several geographies. The global risk aversion of a company may vary with the level of global risk diversification. [15]

Table 5.1 Continued

Failure Modes and Effects Analysis (FMEA) [41]	FMEA is a design approach to identify the importance and robustness of a design component.	Use means of identifying issues within current enterprise structure, may offer insight toward a firm component that causes a major issue	Not a means of valuation, purely qualitative results
Triangular Distribution [38]	The triangular distribution is a statistical distribution geometry characterized by a minimum, maximum, and mode value. Practitioners of the suggested model architecture in this study may use this component in random variable characterization.	Easy to elicit from managers, offers a way to create highly skewed distributions that may characterize certain risky cash flows or lead times	Managers may misunderstand mode and mean differences during elicitation procedures
Beta Distribution [38]	The beta distribution, similar to the triangular distribution, can be characterized by knowledge of minimum, maximum, and mode values. Analyst may prefer the beta distribution's nonlinear probability density function (PDF) to the triangular distribution.	Easy to elicit from managers, offers a way to create highly skewed distributions that may characterize certain risky cash flows or lead times, uses nonlinear PDF	Managers may misunderstand mode and mean differences during elicitation procedures

CHAPTER VI

CONCLUSIONS AND FUTURE RESEARCH

6.1 Conclusions

This study surveys the numerous aspects of global sourcing of manufacturing. In particular, the discussion of offshoring describes an option that can be supportive or detrimental to the overall goals of a corporation. Though many companies have succeeded with their offshore strategies, some corporations have reshored or nearshored their operations in response to the difficultly associated with managing long supply chains. These companies illustrate that globalization can be a two-way street – some organizations are best suited for domestic operations. The impetus of the study stems from the reshoring trend: how does a company decide if they are a good candidate for offshoring? The complexity of the global sourcing decision results from the many factors related to the problem; most reasons for failed offshore strategies originate from supply chain volatility and environmental impacts. With the levels of external uncertainty inherent to the global market, controlling uncertainty proves to be a valuable trait among internationally sourced corporations. An ESE viewpoint, therefore, provides emphasis throughout the study on the interrelationships and variability native to the offshoring problem. Figure 6.1 describes an overall perspective of the offshoring problem; its contents explain the primary facets of this study.

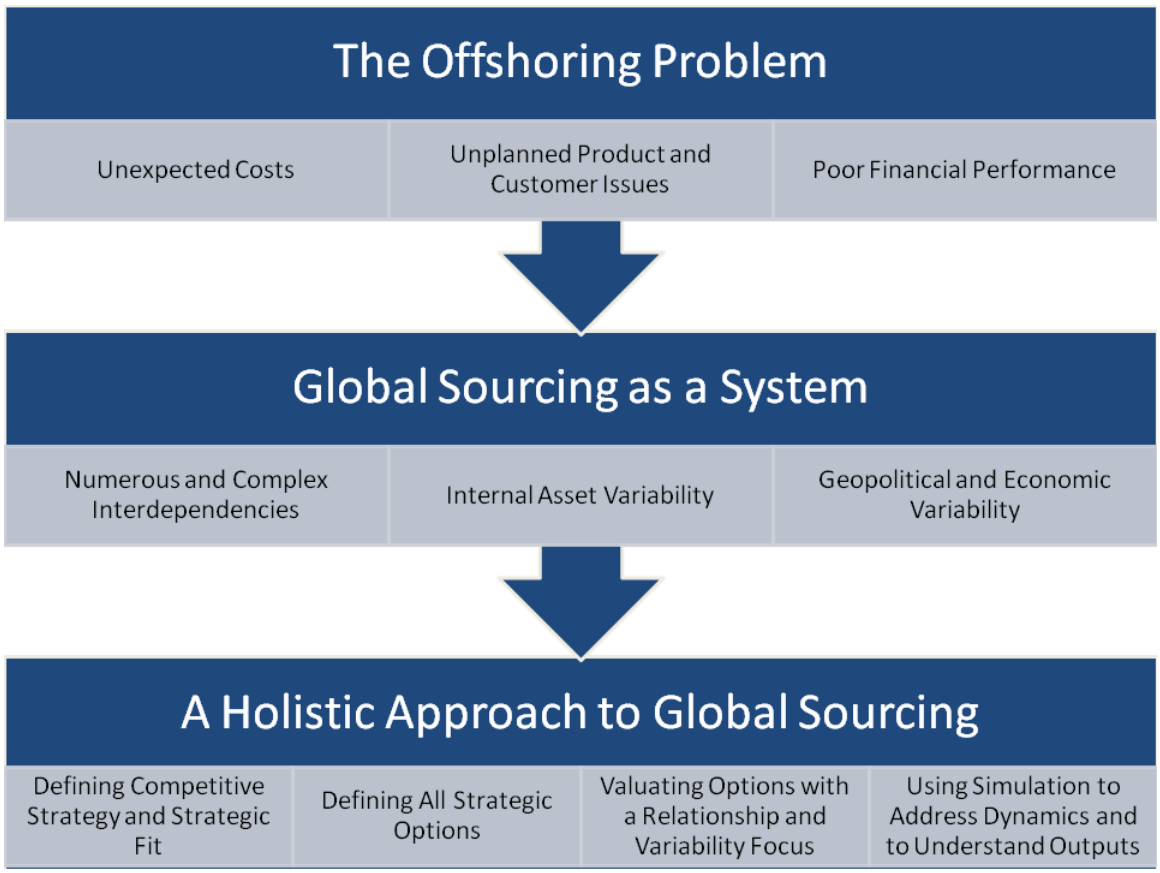

Figure 6.1 Summary of the Offshoring Study

Even so, to say which production sourcing choice for a company is the best choice is a difficult question to answer. The decision process needed to answer this question requires a holistic approach that takes into account the total competitive strategy of a corporation. Furthermore, a system that valuates different strategies can serve as a useful tool to corporate decision makers if it impartially values risks, lost opportunities, and long-term forecasts among several options. Because of the many relationships, internal and external, natural to global manufacturing units, system dynamics simulation provides a logical means for encapsulating the decision, cash flow, and uncertainty structures at a top-level perspective. Furthermore, the inclusion of the Monte Carlo sampling methods addresses the uncertainty among several options.

A few notable findings in the study relate to the current trends in global business. First, full-fledged offshoring is normally a poor strategy for companies that value high quality standards, customization, extended customer services, and intellectually unique products. These characteristics are difficult to maintain beyond international boundaries; companies that illustrate successful offshoring strategies while still upholding these traits are normally large industry leaders that exhibit global risk diversification. Second, offshoring needs to remain a sourcing strategy within the larger competitive strategy. The tactical use of offshoring to save costs generally backfires; that is, globally sourced companies need to dedicate themselves to succeeding at a global strategy. Finally, companies that suffer from competitive pricing should look to several avenues for increasing corporate worth. Cutting costs via a Low-Cost Country Sourcing strategy is only one option; design collaboration, inventory management, extended customer service, and high product quality are opportunities outside of LCCS that may provide desirable results for the company.

6.2 Future Research

Several future research opportunities materialize from this study. Some notable avenues for further investigation are in the following list.

1. The system dynamics simulation model with Monte Carlo methods discussed in Chapter V needs elaboration from the aspects of mathematical formulation, system architecture, and user interface. Reaching a detailed understanding of modeling the sourcing decision would lead toward a decision assistant tool for application to industry.

2. Best practices for uncertainty modeling are an important research area. The types of risks inherent to global sourcing need quantification in an easy and uniform manner. Furthermore, some general risks, such as exchange rate phenomena and fuel prices, can be characterized for industry practitioners. An Uncertainty Model template would be a powerful tool for industry application.
3. A case study surveying a recently reshored company may provide a method for validating a decision assistant that employs system dynamics simulation.
4. Multishoring[72] are strategies that offer complex decisions. Creating a system dynamics decision assistant for industry players interested in these strategies serves as another research avenue. Companies could decide the amount of demand that should be allocated between domestic and foreign facilities in a strategy that hybridizes onshoring and offshoring.
5. Due to the success and popularity associated with process improvement methodologies in the U.S., research toward a new improvement methodology for collaborating global manufacturing and overall corporate goals may be appropriate.

[72] *Balanced Multishoring*[72] is a form of dual sourcing in which a firm allocates a static portion of demand to foreign manufacturing facilities while allocating dynamic demand to domestic facilities. The goal of multishoring is to combat demand volatility losses across global supply chains by leveling demand to dedicated manufacturing facilities located in foreign countries; meanwhile, agile manufacturing facilities in a domestic setting handle volatile portions of demand without need of transferring items across a global supply chain. Thus, companies are able to leverage dedicated manufacturing qualities and agile manufacturing qualities in a symbiotic manner. [19]

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APPENDIX A

TERMINOLOGY

A.1 Glossary of Terms

Asset-Level Variables are uncertain input variable within the Cash Flow Model independent of external economic performance. Examples are success of a new R&D technology, the major infringement of an intellectual property, or (insourced) production lead time. [25]

Backshoring is a synonym of *reshoring* [42].

Balanced Multishoring[73] is a form of dual sourcing in which a firm allocates a static portion of demand to foreign manufacturing facilities while allocating dynamic demand to domestic facilities. The goal of multishoring is to combat demand volatility losses across global supply chains by leveling demand to dedicated manufacturing facilities located in foreign countries; meanwhile, agile manufacturing facilities in a domestic setting handle volatile portions of demand without need of transferring items across a global supply chain. Thus, companies are able to leverage dedicated manufacturing qualities and agile manufacturing qualities in a symbiotic manner. [19]

Business Divisions represent hierarchal levels of a company; the Rummler and Brache organizational framework references three levels of business division: organizational, process, and performance levels [20].

Business Functions represent different areas of competence within a company; these include human resources, manufacturing, and information technology.

Control Variables for Strategy numerically define a strategic option. Common categories of control variables include flexibility controls, target demographic choice, perceived product characteristic value, and labor compensation rate for a location.

Cross-divisional Communication is internal company exchanges of information that imply a level of business being enabled and controlled by a higher division.

Currency Transfer Risk causes uncertainty in a cash flow due to transfer of funds between nations; this exchange subjects the cash flow to a volatile exchange rate [15].

Decision Flexibility refers to the amount of future decision options that management may have within a strategy. More future option entails higher decision flexibility.

Dedicated Manufacturing is a production strategy with minimized *production flexibility* in order to exploit economies of scale.

[73] The authors credited with this information do not use this term in their study; *Balanced Multishoring* appears as the term in the current study in order to offer nomenclature uniformity among other named concepts such as *offshoring* and *reshoring*.

Design for Manufacture and Assembly (DFMA) is a product and operations strategy that emphasizes major collaboration between the production and design functions of a company in order to ease manufacturing complexities while still maintaining overall product design goals. Lower costs and higher product value potentially result from DFMA. [4]

Discounted Cash Flow Model (DCF Model) is the general valuation approach. In DCF methods, expected levels of cash flow expressed as a present value are calculated via a per-period compounded discount rate. The discount rate reflects the time-value of money as well as corporate asset risk. [33]

Dual Sourcing refers to a company using two sources to fulfill a supply (or service) need. Normally, supplier redundancy aids in supply chain issue resolution [19].

Economy-Level Variables are uncertain inputs in the Cash Flow Model that heavily correlate to an overall economic trend. Examples include fuel costs, demand forecasts, and supplier lead times [25].

Enterprise Systems Engineering is the cross-disciplined study of organizations as systems; its application toward a company focuses on strategic organizational design for emerging markets and their resultant challenges [1].

Global Risk Diversification entails that a large company has many global investments in several geographies. The global risk aversion of a company may vary with the level of global risk diversification. [15]

Global Sourcing Strategies are strategies that use international resources to fulfill a need. Global sourcing strategies included intercontinental sourcing of production, or *offshoring*.

High Cost Country Sourcing (HCCS) is a competitive strategy that emphasizes the use of costly manufacturing in order to guarantee company characteristics other than low cost. The primary goal of HCCS is to provide products with value-added services, complex intellectual property characteristics, and high quality. With these tenants upheld, firms are able to earn higher margins from sales and earn consumer respect from service and quality standards. [10]

Holism is "the idea that a system exhibits properties and behavior that cannot be attributed to any one of its parts" [2].

Inshoring is a synonym of *onshoring* and, in some cases, *reshoring* [43].

Insourced Offshoring is the vertical integration of a global supply chain; large companies that own an intercontinental manufacturing facility pursue an offshore insourcing strategy.

Insourced Onshoring is the vertical integration of supply chain activities. In the case of this study, onshore insourcing represents a company that owns its manufacturing facility.

Insourcing is an organization's choice to own and to operate a functional role necessary to serving a customer. Insourcing many key functions results in a vertically integrated supply chain.

Low-Cost Country Sourcing (LCCS) is "companies… shifting their repetitive and lower-value work to more economical locations in an attempt to compete on lower prices" [10].

Market-based Valuation (MBV) is a corporate valuation technique that relates market variables to internal company cash flows. In addition to dealing with market sources of risks, MBV appropriately addresses decision flexibility in similar fashion to *Real Options Analysis*. [25]

Nearshoring is an organization's use of a foreign but continental region's labor resources to serve customers in a domestic setting. Nearshoring may entail lengthening a supply chain by leaving domestic operation (i.e., cheapening labor rates) or may entail shortening a supply chain through abandoning offshored operations (i.e., leaning supply chain). Most commonly, nearshoring balances the geographical length of a supply chain with labor compensation costs. In addition, a company's choice to pursue nearshored operations but still maintain its current intercontinental operations is considered a nearshoring strategy. [16]

Offshoring is an organization's use of an intercontinental region's labor resources to serve customers in a domestic setting. Generally, offshoring leverages low cost labor resources in order to develop a cost advantage over domestic counterparts. Offshoring is a type of manufacturing sourcing strategy. [27]

Onshoring is a production sourcing strategy in which a corporation uses its country of origin for its manufacturing location. Its main difference from reshoring is its focus on original choice versus reversal. A company that has no global manufacturing strategy is onshored; meanwhile, a company that begins to move production facilities to a domestic setting exhibits reshoring. [44]

Outsourced Offshoring is exhibited by companies that use intercontinental manufacturing facilities but purchase the production service from a third party.

Outsourced Onshoring is a company's purchasing domestic services to fulfill a function outside of its core competency.

Outsourcing is an organization's use of a separate company to complete a task necessary to serving a customer. Outsourcing is a typical choice for companies that lack expertise or capital assets for a particular function. [45]

Process Management includes the design, control, and improvement of a business entity; understanding these three roles is essential to meeting high quality operations, to discovering areas in need of improvement, and to meeting high customer expectations. Process Management stems from the "Quality Trilogy" founded by Joseph Juran. [26]

Production Flexibility refers to a manufacturing system's ability to adjust to different levels of production capacity and to accommodate a diversified product portfolio.

Real Options Analysis (ROA) is a corporate valuation technique designed to value decision flexibility. A real option represents a future decision that is based on internal or external factors that have different chances of occurring. Common real options include opportunities to expand or to contract operations, to delay or to accept project initiation, or to diversify or to consolidate production characteristics. ROA is a component of the general *market-based valuation* approach. [35]

Reshoring is the replacement of an *offshoring* strategy with domestic production operations. Reshoring actions may consist of partially removing foreign operations from the organization. In addition, a company's choice to discontinue expansion with offshored labor but still maintain its current foreign operations is considered a reshoring strategy. [22]

Risk-adjusted Discount Rate (RADR) is a discount rate used in the *DCF Model* that has been augmented to account for risks beyond those encompassed by a firm's cost of capital. RADRs assume that risks higher than cost of capital values should compound per period similar to time-value of money. [34]

Risks are causes of *uncertainty* in variables. A significant risk in a variable may entail the need to quantify the level of uncertainty in the variable.

Sourcing is "the entire set of business processes required to purchase goods and services" [11]. In the case of global sourcing for production, labor markets represent "purchased" goods and services.

State Variables define the market and company conditions in a *market-based valuation* model. State variables provide feedback that affects expected financial performance for a company. State variables can be *asset-level variables* (internal to the firm) or *economy-level variables* (external to the firm). [25]

Strategic Fit is the collaboration of all company (or value chain) strategies [11].

Structural Costs are those business expenses that must be accepted by the manufacturer based on the sourcing location. These types of costs directly relate to political standards of the sourcing destination. Jeremy Leonard defines structural costs as labor compensation, corporate tax, pollution regulation, energy prices, and tort litigation. [13]

Supply Chain Flexibility refers to the ability of a company to adjust to volatile shifts in variables associated with the supply chain. The variables include customer demand, fuel prices, supplier failure rates, etc.[16]

Uncertainty implies a quantified value of *risk* or variability in a value; uncertainty can be expressed as a margin of error about an expected value or may imply a more detailed distinction through statistical distribution.

A.2 Discrepancies in Terminology

Since global sourcing has recently become a more prominent financial issue in the United States, numerous writers and research contributors have created several new sourcing terms. In this section, the discrepancies among some terminology is discussed.

"Offshoring" is potentially the most important word used in this study. However, users need to be aware that "outsourcing" (the use of another service provider) is different from "offshoring" (the use of intercontinental labor). For example, Meeker and Dewhurst use "outsourcing" to refer to offshoring [4]. Since offshoring strategies may include outsourcing (as the two options are not mutually exclusive), the need for distinction between the words is paramount. Furthermore, users need to distinguish between insourced and outsourced offshoring cases. Giachetti claims, "If the company the work is outsourced to is in another country, then it is call off-shoring." Giachetti should say that the described situation is "outsourced offshoring" since vertically integrated companies may also have foreign manufacturing usage internal to the company. In addition, Giachetti uses the hyphenated "off-shoring" version of the term (which is not recommended in this study).

Derivatives of "reshoring" include "onshoring", "inshoring," and "backshoring." Though consistency is not prevalent in current literature, this study prefers the use of "onshoring" to represent an original choice to locate manufacturing domestically while using "reshoring" to represent the reversal of a long-term choice to use an offshore sourcing strategy.

The White House illustrates terminology discrepancy in the use of "insourcing." They define the term to include both "reshoring" and "onshoring" definitions [46]. Neither word describes insourcing, which should naturally define the opposite situation

of outsourcing. "Insourcing" implies vertical integration; meanwhile, "reshoring" or "onshoring" imply geographical choice. Since its nomenclature can literally be interpreted as the opposite of "outsourcing" simply by its spelling, "insourcing" should describe ownership but not geographical choice. In order to eliminate confusion in this study, four terms that imply both ownership and geography of the sourcing choice are introduced: "insourced onshoring," "outsourced onshoring," "insourced offshoring," and "outsourced offshoring." In addition, the term "Multishoring" is introduced to represent the dual sourcing of manufacturing described by Beeland [19].

APPENDIX B

EXCHANGE RATE CONSIDERATIONS

Exchange rates offer a decision component unique to international sourcing among manufacturing source options. Currency risk is an important characteristic to include in the valuation of global sourcing strategies, but objective incorporation into the result is difficult to achieve. In fact, several sources seem to avoid detailed discussion of the matter; however, Donald Lessard describes currency risk by listing it as three separate categories in his paper "Incorporating Country Risk in the Valuation of Offshore Projects." These categories are

1. Currency volatility risk, which represents the systematic fluctuation in the value of a fiat;
2. Currency depreciation risk, which represents biased fluctuation in the value of a fiat; and
3. Transfer payment risk, which represents the reevaluation of a cash flow from international exchange [15].

Lessard, who is also a contributor to the MBV methods described in the study, says that volatility and depreciation risks usually should not be included in valuation. The author omits these categories for several reasons, but the impetus for a lack of concern over these categories is their relatively low risk premiums. However, transfer payment risk offers a different problem; since each country's political system plays a large part in valuing currency in addition to the free market, this type of risk is political in nature. [15]

The role that central banks play to counteract free market exchange values significantly affects offshoring decisions. Low-valued foreign currency implies better financial opportunity for foreign investors; therefore, countries that desire to increase exports can use a central bank policy to lower the value of their native currency. The

Chinese Yuan, on which the free market has little affect due to China's command economy structure, is the most evident example of "artificial" devaluation in order to promote foreign investments. Some sources estimate that the Yuan is valued as much as 50% below its free market price [3]. This type of issue, though, is more closely related other political risks, such as corporate tax and tariffs, than to currency risks. Undervalued fiat currency is essentially a "tariff credit policy" applied through currency value rather than traditional means. David Jacoby of Boston Strategies International claims "If the U.S. dollar continues to depreciate against the Chinese Yuan, this could begin to tilt the balance in favor of sourcing from domestic and U.S. companies" [10].

With an understanding of this political risk, companies that are considering an offshore strategy need to be familiar with the points of currency exchange (i.e., cross-border transfer payments) within their cash flow structure. Moreover, some firms may wish to consider long-term stability of their offshore strategy in the event of major exchange rate fluctuations – either as U.S. dollar losses or as foreign currency gains.