**Development of a Total Landed Cost and Risk Analysis Model for Global Strategic Sourcing**

by

**Brian Feller**

BS Industrial Engineering, Texas A&M University, 1995

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

**Master of Business Administration**

and

**Master of Science in Engineering Systems**

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## Abstract:

Total landed cost and supply chain risk analysis are methods that many companies use to assess strategic sourcing decisions. For this project, landed cost is defined as those costs associated with material movement from a supplier to a designated PerkinElmer, Inc. (PKI) manufacturing site. Tools or models that are available in the technology marketplace are often too cumbersome to incorporate with a company's existing technology architecture or are too simplistic to compute an accurate landed cost. For PerkinElmer, as their Analytical Sciences business continues to grow globally, they are continuously reviewing their supplier portfolio and assessing their procurement strategy.

The landed cost and risk analysis tool consists of two components, a cost model and a risk analysis model. Both models were developed to allow PKI to better understand the savings opportunities associated with a supplier selection. When performing supply chain modeling and cost optimization, it was necessary to be able to evaluate multiple scenarios that can influence a sourcing decision. Therefore, by changing parameters such as transportation mode, lead time, inventory carrying cost, freight cost, order frequency, and order quantities in the dynamic cost model, PKI is able to understand supply chain cost trade-offs. The model developed for this project is dynamic to allow multi-variable scenarios to be assessed simultaneously, thus increasing the overall analysis efficiency.

For the risk analysis model, approximately 20 different factors were considered as a part of a risk portfolio. This concept adapts traditional financial investment portfolio management theory by considering how much operational impact one factor may have on PKI. The concept is to consider a diversified portfolio, so all of the possible risk incurred by a sourcing decision does not reside in any one "category" (logistics, inventory, etc.). The outcome of the model is an index and adjusted cost, providing PKI with an estimate of the potential cost of doing business with a supplier based on their risk profile.

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I would like to thank my thesis advisors, Don Rosenfield and David Simchi-Levi. Both were invaluable throughout the project, providing me guidance, subject matter expertise, direction, and feedback. Their dedication to the project and interest in the outcome allowed me to exceed my expectations for the project. Also, I would like to acknowledge the entire Leaders for Manufacturing Program for its support of this work.

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I would also like to acknowledge the tremendous support I have received from my executive sponsors at Dell, Inc. I am grateful for their dedication to my continued education and leadership development.

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## Biographical Note:

Brian Feller was born in Everett, Washington and has lived in various parts of the United States, including California, Idaho, Connecticut, Texas, and Massachusetts. Brian attended Texas A&M University and received a BS in Industrial Engineering. While at Texas A&M, Brian was an intern at Perot Systems where he developed simulation models for a variety of applications. Brian started his professional career with Arthur Andersen Business Consulting and focused on Supply Chain and Operations consulting for over six years. His experience included work in many different industries, including Consumer Electronics, Telecommunications, Pharmaceutical, Oil and Gas, and High Tech. Prior to coming to the Leaders For Manufacturing program at MIT, Brian worked for Dell, Inc. as a Strategy Manager, Operations Supervisor, and Master Scheduler. While at Dell, Brian earned his 6-sigma Green Belt certification and served as a mentor for other 6-sigma project leaders.

Brian is an avid golfer and sports fan who enjoys home improvement projects, landscaping, and travel. Upon graduation in June 2008, Brian will be continuing his employment at Dell, Inc.

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# Chapter 1: Company Background

PerkinElmer, Inc. (PKI) is a leading provider of scientific instruments, consumables and services to the pharmaceutical, biomedical, academic research, environmental testing and general industrial markets, commonly referred to as the health sciences and photonics markets. They design, manufacture, market and service products and systems within two businesses, each constituting a separate reporting segment:

- *Life and Analytical Sciences (LAS).* The LAS business provides precision instrumentation, reagents and chemistries, software and services for a wide range of scientific and industrial laboratory applications, including genetic screening, drug discovery and development, environmental monitoring, food and beverage quality, and chemical analysis.
- *Optoelectronics.* PKI provides a broad range of digital imaging, sensor and specialty lighting components used in the biomedical, consumer products and other specialty end markets.

The health sciences markets include all of the businesses in the Life and Analytical Sciences segment and the medical imaging business, as well as elements of the medical sensors and lighting businesses in our Optoelectronics segment. The photonics markets include the remaining businesses in the Optoelectronics segment.

PKI is a global manufacturer with each site (shown in Figure 1) manufacturing unique products to complete the company product portfolio. Generally, manufacturing volumes tend to be relatively low, while the variation in product, or product mix, tends to be very high. PKI provides a very broad portfolio of products tailored to meet the specific needs of scientists. As a result of this manufacturing strategy, procurement volumes are often relatively small, ranging in quantity from 50 to 2,000 per year. However, demand tends to be relatively predictable, which enables PKI to pursue strategic buys, forward buying, and longer-term supplier relationships.

Figure 1: PKI Global Manufacturing Sites[1]

PKI is a Massachusetts based corporation, founded in 1947 with headquarters in Waltham, Massachusetts. Currently, PKI markets products and systems in more than 125 countries, employs approximately 8,500 employees worldwide, and has revenues of approximately $1.55B. The information provided above and additional information about PerkinElmer, Inc can be found at www.perkinelmer.com.

[1] Background and additional information on PerkinElmer, Inc. can be found at www.perkinelmer.com

## Chapter 2: Project Orientation

PerkinElmer originally proposed a project to develop a total landed cost model to assist the organization with making strategic sourcing decisions. For the purposes of this project, total landed cost is defined as the major cost factors associated with procuring, moving, and storing material between a supplier site and the designated PKI manufacturing site. The original scope of the project was to include those manufacturing sites that are associated with the EcoAnalytix division of the Life and Analytical Sciences (LAS) business only. Specifically, these sites are located in Shelton, Connecticut, Llantrisant, Wales, and Singapore. Ideally, the outcome of the project would incorporate the operational uniqueness associated with each of these sites and to make the model scalable for other business segments.

Due to the growth through acquisition that PerkinElmer has experienced throughout its history, the many acquisitions and divestitures have resulted in an exhaustive but fragmented supply base with many suppliers providing materials to each of the individual PKI manufacturing sites. PKI needed a sourcing tool that would help them evaluate this supply base, considering a comprehensive list of costs and risks, and support the corporate strategy to consolidate suppliers and leverage spend among strategic suppliers.

The project was championed by the Global Strategic Sourcing team and was based in the Shelton, CT site. However, many of the other LAS sites were heavily involved in the project. Shelton was chosen because it contributes approximately 50% of the sourcing cost annually to the LAS business.

The expected outcome of the project was a technology enabled model that would be available to all geographic regions and PKI manufacturing sites to evaluate sourcing costs and decisions. Knowledge of the model and its functionality would be transferred through user documentation, training, and project involvement by subject matter experts and model users. Ultimately, the primary means of determining project success were the accuracy and utility of the model, adoption by purchasing and sourcing teams, and support/buy-in from business functions that were represented in the model

In the following section, the specific objectives of the project will be outlined.

## 2.1 Project Objectives

At the outset of the project, there were nine primary objectives established by the project team.

1. Facilitate global sourcing decisions by including major costs associated with a supplier selection in a simple to use model – The intent of the model was to be as comprehensive as possible and to include as many relevant costs that would contribute to the sourcing decision. Ultimately, including every cost was not feasible, but those that were included contributed the most significant portions of cost.
2. Create a common supplier evaluation tool for all global manufacturing sites – By including three LAS sites, the site's processes, data requirements, and supplier challenges will be included in the model.
3. Standardize the supplier selection process – By consolidating demand and supply requirements for each site and engaging common suppliers, PKI can leverage their global buying power and pool risk from demand variability.
4. Promote supply chain risk to be considered in sourcing decisions – Each supplier goes through an initial evaluation process, but PKI did not have a standard process that could be used to consider supplier risk in the sourcing decision.[2]
5. Leverage spending with suppliers capable of developing long-term partnerships with PerkinElmer – Many times suppliers may be chosen for their long-term partnership capabilities. To support these decisions, PKI wanted a model that would help evaluate supplier cost and risk when establishing these partnerships.
6. Engage suppliers in low-cost countries after balancing landed cost, supply chain risk, and material complexity – One of the original intentions of the model was to confirm the benefits of using suppliers in low-cost countries. However, the overarching objective was to understand the cost differences between suppliers anywhere in the world, not just low-cost countries.

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[2] In a recent survey among CEOs and COOs, managing supply chain and supplier risk is the number one concern. "Executive Issues Survey, April 2006, Accenture and "Countering the Risk of Offshoring & Lean Manufacturing, Simchi-Levi, 2008 MIT Risk Management Conference

7. Raise awareness of the impact on sourcing decisions related to all other cost factors beyond material cost (e.g. trade compliance, finance, inventory, etc.) – As mentioned above, PKI made sourcing decisions, in the past, primarily on material cost variance. Going forward, PKI desired to have a much more comprehensive view of costs to make strategic sourcing decisions.
8. Provide a learning opportunity for the entire project team – Many concepts and methodologies used in the model are new to the PKI team. Using the model provided an opportunity for each team member to grow their skills and knowledge of global supply chain processes, risks and cost.
9. Utilize the DMADV (Simon) (Define, Measure, Analyze, Design, and Verify) 6-sigma project execution methodology – This process is a slight variation of the more commonly used DMAIC (Define, Measure, Analyze, Improve, and Control) process, but is more appropriate for this project. The DMAIC process implies an improvement over an existing process while the DMADV process implies a new design or process is being established. Since PKI did not have a formal strategic sourcing model in place, the design and verify steps were critical to ensure the model was accurate and robust in its capabilities.

# Chapter 3: Literature and Supply Chain Model Review

Prior to developing a landed cost and risk model, a significant amount of research was conducted to understand models that have been developed in the past, processes for assessing risk, cost components that should be considered in a landed cost model, supply chain risk studies that have been done and how they might be incorporated in the model, theories on strategic sourcing, and the differences between total cost of ownership (TCO) and total landed cost. There are many articles that focus on these topics, especially dealing with risk management. Many state statistics on revenue loss and operational challenges that arise when supply chain disruptions materialize. Some models are heavily focused on statistical analysis while others are qualitative and more strategic in nature. The challenge when dealing with developing a complex model is striking a balance between a robust, comprehensive design and ease of use. In the following sections, research on landed cost and risk assessment will be reviewed, focusing on the analysis and findings that influenced the development of the landed cost and risk model presented in this thesis.

## 3.1 Risk Management Research

Many articles have been written about the inherent risks of conducting business on a global basis. Commonly researched risks include geo-political risk, natural disasters, transportation capabilities and currency volatility. More broadly, risks are often categorized as physical, financial, relational, intellectual property related and innovational, but generally describe random events that may impact an organization (Fiskal and Rosenfield 1-8). All of these types of risks are included in the model developed for PKI. Interesting research done by Tuomo Aho describes "Wolfe's Paradox" as the situation where supply chains are designed to be robust, but are fragile at the same time because of the interdependencies and risks inherent within numerous supply chains, and often times those dependencies may only become apparent in a crisis (17). The paper also discusses the importance of Business Continuity Management (BCM), which will be supported by the model described in the following chapters. Creating awareness of the most critical risk factors supports development of mitigation strategies and recovery plans throughout the organization. The model developed for PKI attempts to strike a balance between cost and risk management, by creating a tool that integrates both to understand the potential impact of identified risks and by helping prioritize mitigation activities. Although risk management is well-researched and studied, a survey of purchasing executives in 2004 reported that only 50% monitor supply chain risk often while 30% monitored risk rarely (de Waart 27-33). As lean and Six Sigma practices have reduced inventory levels, a traditional buffer against risk, throughout the value chain, executives are beginning to dedicate more attention to understanding supply chain risk. Consequently, many companies are tempering their lean initiatives because supply chain and transportation reliability around the world do not support the aggressive goals initially set for inventory reduction. In a 2005 report by the Council of Supply Chain Management Professionals (CSCMP), it was shown that inventory levels are rising to buffer against risk (Crone 28-35). However, inventory accumulation cannot be the sole counter measure to risk. The model developed for PKI helps to understand the trade-offs of inventory cost with logistics, materials, and other costs and associated risks. Understanding these trade-offs and prioritizing risks associated with each supplier is critical to maintaining supply continuity.

Many risk management models attempt to prioritize risks relative to each other to create a hierarchy structure. One model by Sarkis and Talluri suggests a sourcing decision maker use pair wise comparisons of risks to determine which is more important (18-20). As opposed to establishing a hierarchy of importance, the model developed for this project considers all risks in a portfolio, making a specific contribution to the overall risk of working with a particular supplier. Like an investment portfolio, risks will perform differently over time (Hauser 64-71). The key to using the model effectively is understanding how adverse effects impact cost at a particular time, recognizing business processes that need to change to manage risk, and revisiting supplier risk profiles regularly to align mitigation strategies with current market conditions.

Another challenge in managing risk is working with suppliers in low cost countries and understanding their capabilities. One of the most important steps in identifying capable suppliers is to have a set of criteria and qualifications that include historical, financial, operational, service and reference information that will help discover shortfalls, risks and strengths in the relationship (Derocher 1-6; Sarkis and Talluri 18-20; de Waart 27-33). By using supplier information in a quantitative manner, PKI will be able to establish their risk mitigation strategies. Such strategies may include speculative strategies (i.e. using a single alternative), hedge strategies (i.e. balancing risks among multiple sources or locations), or flexible strategies (i.e. using multiple suppliers, manufacturing locations, etc.)(Kogut 27-38). One approach, which was used in this project, is to normalize the risk scale used for evaluation purposes and to enable a relative risk score to be calculated (called risk utility in the PKI model) (de Waart 27-33). In the article, the idea of weighting each risk factor is introduced, but cautioned due to subjectivity. In the model created for PKI, weight factors were included using a method that minimizes subjectivity.

Many sources were used to determine what risk factors should be included in the model. Subject matter experts, literature, surveys, and industry best practices were considered. One specific survey used was presented at a recent conference at MIT. Accenture offered data from their 2006 Risk Management Survey that showed how over 150 practitioners thought specific risk factors and levels would change in the next three years (shown in Figure 2). Each of the sources mentioned above contributed information and justification for the many factors which have been included in the model.

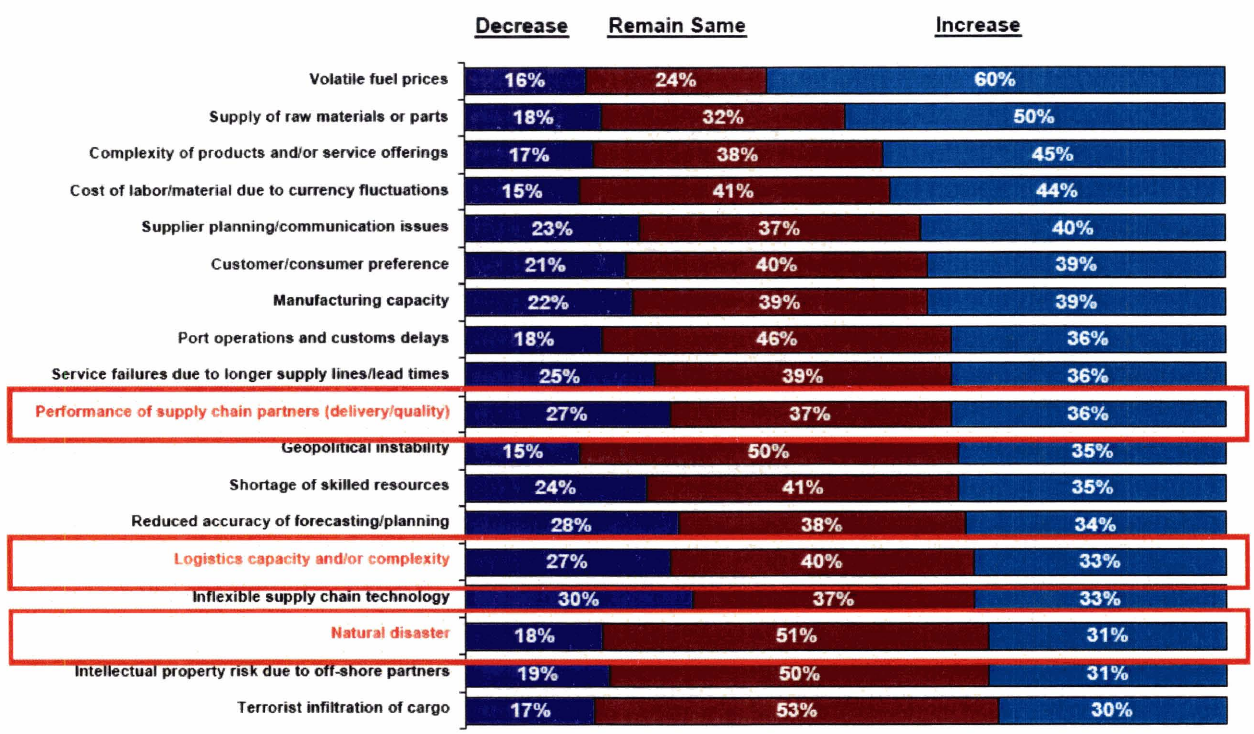


Figure 2: Industry Risk Survey Results (Rodysill)

Risk-adjusted cost models have also been developed, but defined differently than the model developed for this project. An application provided by Vivecon[3] focuses risk management on demand and supply imbalances. Other models have defined risk-adjusted cost as including "fully-loaded" material price, inventory costs, shortage costs as well as probability of inventory shortages and backlog levels impacting total cost (McBeath and Kessinger 1-6). Again, these models focus on costs that are quantifiable over time. The model developed for PKI considers these risks as well as those that have an indirect impact on cost, such as organizational structure, trade compliance, currency volatility, financial position of a supplier, etc. By calculating a total cost that adjusts for the cost of various risks, sourcing teams can be much smarter in evaluating alternatives (McBeath and Kessinger 1-6).

In addition to this thesis, several other projects were being conducted as part of the Leaders for Manufacturing (LFM) program at MIT that related to strategic sourcing. Projects at The Boeing Company, United Technologies, ABB, and American Axle Manufacturing considered risk management, total cost assessment and strategy development. Throughout each project, project leaders collaborated on key issues and risks that were common among a variety of manufacturing industries. Common risks included supply chain delays and disruptions, demand variability, currency volatility, geo-political risks, intellectual property risks, quality, technology capability, and inventory management. Many of the risks included in the model developed for PKI were also relevant for other operational challenges such as global outsourcing, manufacturing plant location selection, and strategic supplier selection. Since many companies are considering suppliers in low-cost or emerging countries and with significant commodity price volatility, identifying and understanding the risks associated with these decisions is becoming more complex and challenging (Teague 60-64). Past LFM theses also contributed to the approach taken for this project. As Mr. Morita points out in his thesis on total cost, there are numerous approaches that can be taken to developing a cost model. Alternative approaches include using Total Cost of Ownership (TCO), activity based costing or transaction costing, supplier/order/unit level functions, or a comprehensive model considering hundreds of cost components. Mr. Morita chose a change in cash flow analysis as opposed to an absolute cost calculation and utilized a

[3] Vivecon Online. 2006. Vivecon Company Information. 15 October 2007.
<http://www.vivecon.com/products/index.html>

risk common denominator of operational slowdown or shutdown (Morita 17-18). In models developed by Robinson (2) and Wu (2) for Honeywell and Teradyne respectively, landed cost models included only labor and materials, logistics, inventory and taxes and were designed to begin the analysis process of establishing global sourcing alternatives. Unfortunately, no one methodology has proven to be more accurate or inclusive than another.

## 3.2 Landed Cost Research

As total landed cost solutions become more prominent in the market, the scope of what such models include will also expand. Many initial landed cost models included only material and transportation costs. In order to execute global sourcing well, a company must first consider the trade-offs across the four primary sources of cost: material cost, transportation cost, inventory carrying cost, and trade compliance costs. A company that considers all four of these costs in the formula they use to make sourcing decisions is in an excellent position to outperform their competitors' cost structures through global sourcing (Horne 1-5). The model developed for PKI considers each of these costs as well as others that may influence the sourcing decision. Fortunately, technology has continued to advance with leading supply chain software providers such as i2, JDA, and SAP developing landed cost modules. In an article published by Infosys on Landed Cost Optimization, functionality of a landed cost model would need to include transportation mode analysis, import and export charges, tariff charges by country, potential storage charges, multiple currencies, freight term impact on cost, and supplier incentives or discounts (Gummaraju 1-4). Additionally, the ability to do "what if" analysis and compare relative total costs of different scenarios can be very useful when considering the impact of actual product requirements specifications and design thinking (McBeath). The model developed for PKI will allow for these what-if scenarios to be evaluated.

Another alternative for cost modeling is the use of linear programming algorithms. Although these methods are predominately used for optimization, the structures and frameworks can be helpful in identifying cost inputs and attempting to reach an "optimal" business solution, not just an "optimal" cost solution. For example, linear programming algorithms may be used to find results such as the total supply cost, average supply cost, or how much of a part should be purchased from a selection of suppliers. By establishing an objective function, decision variables, and appropriate constraints, a minimum cost can be determined (Bertsimas and Freund 324-424). Similarly, non-linear programs (NLP) may be used to determine expected return or minimum risk possible from a series of investments. NLP may also be used for supplier location strategy to serve global manufacturing sites where lead time, distance, and purchase quantity are all drivers in determining total cost (Bertsimas and Freund 324-424). These optimization strategies may be used for future model development, but the intention of the landed cost and risk model for PKI was not necessarily to minimize the calculated landed cost, but to consider risk and other business factors to make a strategic supplier selection based on all relevant decision criteria.

One challenge in developing a total landed cost model is making the distinction between landed cost and TCO. Since TCO often takes a life cycle view of a product, many costs associated with production, quality, outbound logistics, maintenance, and transactions would be included in understanding TCO. Historically, TCO models have relied heavily on activity based costing (ABC) analysis to properly attribute operational costs to specific parts or materials (Ferrin and Plank 18-29). Given that many of the costs mentioned above are not attributable to the original supplier of the part(s), the model considers only those costs relevant to selecting a supplier.

A specific goal of this project was to provide a tool that would assist with decisions to source material in low-cost countries. As PKI considers low-cost countries, five key criteria must be evaluated; total landed cost, delivery reliability, supply chain flexibility, product design, and regulatory compliance/risk mitigation (Forrest 17-20). A study done by Bain & Co showed that sourcing in low-cost countries may offer material cost savings of 10-35%, but the additional cost incurred from lead time variability and operational delays may quickly erode that savings (Crone 28-35). The model being developed in this project will help PKI understand the trade-offs between material savings, other operational costs and the criteria suggested above to make strategic supplier selections.

## 3.3 Chapter Summary

After reviewing many sources and literature about landed cost and risk management, a common theme has emerged. No one method for evaluating cost and risk has proven to be more accurate or complete than another. Each organization using these tools must establish their own processes and measures for making sourcing decisions using complex models. Given the wide variety of applications and challenges in identifying costs, organizations that recognize the need for a structured approach to make strategic supplier selections will have an advantage over their competition. Thoroughly understanding financial impact and potential risk with a given supplier will provide insight and drive actions that create value for both PKI and its suppliers.

# Chapter 4: Project Methodology and Timeline

As noted in Chapter 2, the project methodology followed the 6-sigma DMADV approach. The methodology is utilized when the intent of the project is to create a new product or process that has not existed in the past, hence the use of the design phase as opposed to the improve phase. Also, when a new product or process is created, the final stage, verify, is used to ensure accuracy and adoption as opposed to ensuring that an improved process is producing controllable and repeatable results. In each of the following sections, the activities conducted in each phase will be reviewed.

## 4.1 Define

The define phase was used to solidify the scope of the project and to ensure that the model being built would initially focus on the Life and Analytical Sciences business, but would be portable to any other business unit. Additionally, during the define phase the detailed timeline of the project was established. Estimated durations, activities, and dependencies were determined and the project plan was articulated to the project management team. Figure 3 shows the project timeline with key milestones.

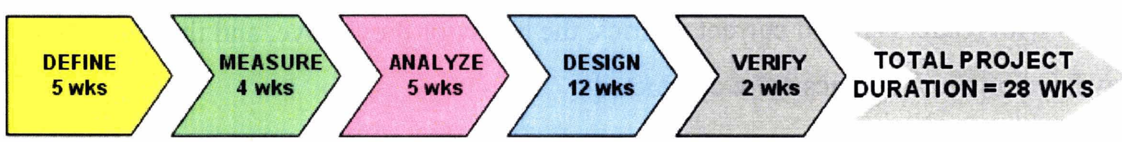


Figure 3: Project Timeline

Specific activities that were conducted during this phase were as follows: operational tours, interviews, focus groups, data gathering, metrics reviews, stakeholder analysis, expectation setting, literature research, and participation in the MIT LFM structured research group focused on strategic sourcing.

## 4.2 Measure

The measure phase was critical in the formulation of the cost and risk components that would be included in the model. To gather data on which costs and risks were most relevant to the business, focus groups, process audits, and data/literature reviews were conducted. The specific areas that were included in the measure phase were inventory management, procurement, sourcing, engineering, quality, operations, logistics, trade compliance, finance, research and development, and legal. Each session with these groups allowed for subject matter experts to explain business processes and the cost and risk factors that each is accountable to manage. Other activities completed during the analyze phase are identified below:

- Measured the availability of historical data, real-time data, or subject matter expert knowledge – As cost components were identified, data sources were identified to understand what historical data, real-time data, or estimates may have to be used in the model.
- Reviewed primary metrics impacted by the model – A primary metric used by the organization was to review the material cost variance between suppliers. The scope of the project would require a paradigm shift on how multiple costs would be considered when making sourcing decisions.
- Completed stakeholder assessment to understand roles, responsibilities, project input, communication methods, and challenges – The model would potentially impact the existing sourcing processes, but would also have an impact on customers and supplier partnerships. Those impacts will be discussed in future sections of this thesis related to the actual cost and risk models.

To begin preparing for the process changes that would be required to implement the model, conversations with leaders around current metrics, the behavior they drove, and the impact the model may have on those metrics were conducted

### 4.2.1 Cost Model Component Identification

During initial interviews and process audits, over 45 cost elements were identified as possible components to the model. It was understood from the initial cost list that many of the costs factors that were proposed by the organization could not be quantified in a sourcing model. After the identification of costs, each was classified as either a "hard" cost or "soft" cost. Eventually, those "soft" costs would be used to develop the risk model. The detailed cost and risk components will be described fully within each section of this thesis devoted to the strategic sourcing model. The specific hard costs that were identified for the model are listed in Table 1.

| Logistics | Trade Compliance | Inventory | Purchasing | Finance |
|---|---|---|---|---|
| Freight | Duty | Average Inventory | Material | Tooling |
| Fuel Surcharge | Tariffs | Safety Stock | Packaging | Payment Terms |
| Accessorial | Customs Fees | Pipeline Inventory | Qualification | Discounts |
| Hazmat | | Warehousing | One-time | |

Table 1: Cost Components Included in Landed Cost Model

After considering the magnitude of these costs, they were the elements that would drive the most significant expense to the organization, and were therefore, used as the primary sources for landed cost. Many other cost factors were considered, but since the model was intended to be a strategic sourcing decision making tool, initial estimates of other cost factors were either too arbitrary to include or were more conducive to be included in the risk model since the costs were too subjective to validate.

During the Measure phase, potential sources of the cost factors listed above were assessed. Those sources included existing contracts, the internet, historical data, supplier input, and static rates used throughout PKI for business case analysis purposes. Following the source identification, subject matter experts were consulted to understand the calculations methods used for each cost. Specific inputs that were requested included PKI cost of capital, interest rate, product demand forecasts, depreciation schedules, etc. The calculations used for each section of the model will be discussed in detail in the modeling section of the thesis.

### 4.2.2 Risk Model Component Identification

As mentioned above, the sourcing model was to include an assessment of risk associated with a particular sourcing decision. It was agreed upon by the project team, that risk would be defined as those elements of the sourcing decision that would impact the supplier selection process but could not be quantified in the cost model. Further, risks that could be described as tactical (short-term impact) and strategic (long-term impact that require mitigation strategies) would be considered in the model (Hopp, Iravani, and Yin). In order to understand those risks that were most relevant to PKI, extensive focus groups were conducted with subject matter experts and individual discussions were held with suppliers to understand the challenges they faced in delivering product to PKI manufacturing sites. The combination of these two sources, along with extensive literature research, which was described earlier, formed the initial list of risks that were considered for the model. At the outset, there were 33 risks identified across the following functional groups: trade compliance, logistics, purchasing, finance, operations, quality, inventory, research and development, and sourcing. The intent of developing an exhaustive list of risks was to ensure that the model utilized a well-rounded approach of assessing risk, and not limit the risk factors to a subset of the overall supply chain.

The next step in assessing the identified risk factors was to use a Failure Mode Effects Analysis (FMEA) (Crow) process to understand the potential risk that each factor would have on PKI should it materialize. An FMEA is traditionally used to understand process failures and the effect they would have on an organization. However, in this case, a modified FMEA can also be used to understand the potential impact of risk factors on an organization. An article published in *Quality Progress* (after a modified FMEA process was developed for this project) confirmed the viability of using an FMEA for such an assessment and suggests that to understand risk factors, having an easily understood identification and analysis process is critical (Welborn 17-21). Specifically, for each risk factor, the severity to the organization, the likelihood of the occurrence, and the processes in place to mitigate the risk can be used to generate a risk priority number (RPN) for each risk factor. Those risks that emerge with a higher RPN are those that, should they occur, will cause the greatest impact to the organization. In the assessment, impact broadly included operational shutdown, overtime to recover from supply disruptions, customer satisfaction, cost increases, revenue loss, employee morale, legal ramifications, supplier relationships, etc. For the FMEA, there are various scales used for each factor identified above. For the purposes of this project, the scales used were as follows:

- Severity → 1 to 7 scale, with a 7 having the most impact;
- Occurrence → 1 to 5, with a 5 being very likely that the risk will occur;
- Detection → 1 to 5, with a 5 being very unlikely that PKI had any mechanism in place to detect or monitor the risk prior to its occurrence.

Therefore, the RPN is calculated as follows: RPN = Severity * Occurrence * Detection

As an example, a risk factor with maximum severity, high probability, and limited a priori detectability would result in an RPN of 175 (7*5*5). As is typical with FMEA analysis, there may be multiple effects or detection mechanisms in place for any one risk, therefore, the process used was to average all inputs for each risk to come up with a final severity, occurrence and detection score. This averaging is evident in Table 2. The final column, entitled "weight" will be described later in this chapter.

After conducting the initial FMEA study, it was determined that several risk factors could be aggregated since they would be evaluated similarly. The challenge was to not make the risk factor too broad so that it became difficult to measure in the model. The final FMEA results are shown in Table 2 and 3.

| | Category | Risk | Severity | Occurrence | Detection | RPN | Weight |
|---|---|---|---|---|---|---|---|
| 1 | Trade Compliance | International trade import/export experience | 5.83 | 4.14 | 2.90 | 70.08 | 9.84% |
| 2 | Purch. / Organizational | Geo-political risk | 5.40 | 3.00 | 3.50 | 56.70 | 7.96% |
| 3 | Finance | Financial strength | 4.57 | 3.00 | 3.60 | 49.37 | 6.93% |
| 4 | Inventory / Quality | Supplier product quality | 4.33 | 2.86 | 3.63 | 44.88 | 6.30% |
| 5 | Purch. / Organizational | Capacity utilization | 4.86 | 3.25 | 2.75 | 43.41 | 6.09% |
| 6 | Inventory / Quality | Inventory requirements | 3.67 | 3.50 | 3.38 | 43.31 | 6.08% |
| 7 | Logistics | Preferred carrier availability | 5.17 | 2.33 | 3.50 | 42.19 | 5.92% |
| 8 | Logistics | Supply chain delays | 4.45 | 3.11 | 3.00 | 41.58 | 5.84% |
| 9 | Finance | Currency volatility | 4.00 | 3.75 | 2.75 | 41.25 | 5.79% |
| 10 | Purch. / Organizational | Strategic supplier/LTA | 3.71 | 3.00 | 3.33 | 37.14 | 5.21% |
| 11 | Purch. / Organizational | Supplier business represented by PKI | 4.00 | 3.13 | 2.89 | 36.11 | 5.07% |
| 12 | Purch. / Organizational | Supplier technology | 3.60 | 3.25 | 3.00 | 35.10 | 4.93% |
| 13 | Purch. / Organizational | Limited experience and incumbency | 3.55 | 2.89 | 3.00 | 30.73 | 4.31% |
| 14 | Purch. / Organizational | Supplier organization structure | 3.00 | 4.33 | 2.33 | 30.33 | 4.26% |
| 15 | R&D | New product development capability | 4.20 | 2.80 | 2.33 | 27.44 | 3.85% |
| 16 | Purch. / Organizational | Supplier supply chain management | 3.58 | 3.14 | 2.20 | 24.78 | 3.48% |
| 17 | Inventory / Quality | Process quality | 3.50 | 2.55 | 2.67 | 23.76 | 3.33% |
| 18 | Purch. / Organizational | Supplier progressiveness | 2.89 | 2.50 | 2.71 | 19.60 | 2.75% |
| 19 | Finance | FDI investment | 3.67 | 3.20 | 1.25 | 14.67 | 2.06% |
| | | | | | | 712.43 | |

Table 2: FMEA Results

| Category | Total Weight | Number of Risks |
|---|---|---|
| Purch. / Organizational | 44.06% | 9 |
| Inventory / Quality | 15.71% | 3 |
| Finance | 14.78% | 3 |
| Logistics | 11.76% | 2 |
| Trade Compliance | 9.84% | 1 |
| R&D | 3.85% | 1 |

Table 3: Risk Portfolio Composition

Specific definitions for each risk factor are included below:

- International Trade Import/Export Experience → The ability of a supplier to understand and correctly provide product valuation, commodity coding, documentation requirements, invoicing, HTS classification, and country of origin identification.
- Geo-Political Risk → The potential that doing business with a supplier in a particular country may be impacted by political changes, governmental instability, or social volatility.
- Financial Strength → For the purposes of this model, the financial strength of a supplier is based on a 3rd party scoring system such as Dun & Bradstreet[4] and is based on a 0 to 10 scale.
- Supplier Product Quality → A number of metrics such as defective parts per million (DPPM), yield analysis, failure rates, delivery performance tracking, and cost of poor quality (COPQ) are used to rank product quality in the model.
- Capacity Utilization → The current estimated capacity position of the supplier.
- Inventory Requirements → The risk factors associated with inventory are those that could not be quantified in the cost model. Such factors include rework capability, warranty terms, and inventory risks related to inventory levels held, which would include damages, scrap, and excess and obsolescence.
- Preferred Carrier Availability → The ability of a supplier to use a PKI preferred carrier such as UPS or FedEx.
- Supply Chain Delays → The likelihood that delivery may be delayed due to natural disaster, customs clearance processes, logistics infrastructure, corruption, etc.

[4] Dun & Bradstreet, Inc Online. Dun & Bradstreet, Inc Company Information. 3 November 2007. <http://www.dnb.com/us/>

- Currency Volatility → Although contracts are likely to be negotiated in USD, Euros or Singapore Dollars, assessing a supplier's local currency is an indicator of the economic conditions that a supplier will be operating under for future contract negotiations.
- Strategic Supplier → The assessment by the Global Strategic Sourcing team on whether the supplier is a candidate for consolidated spend and global partnering versus a supplier that is utilized for a specialty part or small scale production of a particular part.
- Supplier Business (Revenue) Represented by PKI → A measure for PKI to understand the financial position they will occupy with a supplier and to understand how much influence they will have over a supplier.
- Supplier Technology → An assessment of a suppliers ability to partner with PKI in ease of information flow, data management, streamlined ordering and payment processing, manufacturing planning, etc.
- Experience → For the model, experience is evaluated on four points; year over year growth, years in business (longevity), other Fortune 500 companies as customers, and years of experience in the commodity being sourced.
- Supplier Organization Structure → An assessment of the supplier's account management structure, both locally and globally.
- New Product Development Capability → A review of a supplier's R&D capability to understand if they will be able to partner with PKI for new product development, existing product improvement, reverse engineering, or value engineering.
- Supplier Supply Chain Management → Understanding how a supplier measures their suppliers and supply chain is indicative of their ability to meet PKI demand.
- Process Quality → In order to meet product quality standards, process management initiatives are leading indicators of a supplier's ability to deliver quality products. Indicators include ISO certification, work instructions, corrective action processes, equipment calibration schedules, operator metrics, and inventory segmentation.
- Supplier Progressiveness → To achieve cost reduction initiatives, reviewing continuous improvement programs in place at a supplier can be used as an indication of their ability to scale or reduce cost with PKI. Such indicators include 6-sigma, lean, formal safety programs, a formal project management road-map, and formal employee cross-training programs.

- FDI Investment → Foreign Direct Investment (FDI) is a metric that measures the investment being made in a country by outside corporations. Considering FDI takes advantage of other company investment and risk analysis processes that have concluded to do business in a particular geography.

A by-product of the FMEA process is the ability to understand which risk factors have the most potential impact on the business and what mitigation factors are in place for each factor. By using a scatter plot, each component of the RPN, severity, occurrence, and detection can be compared.

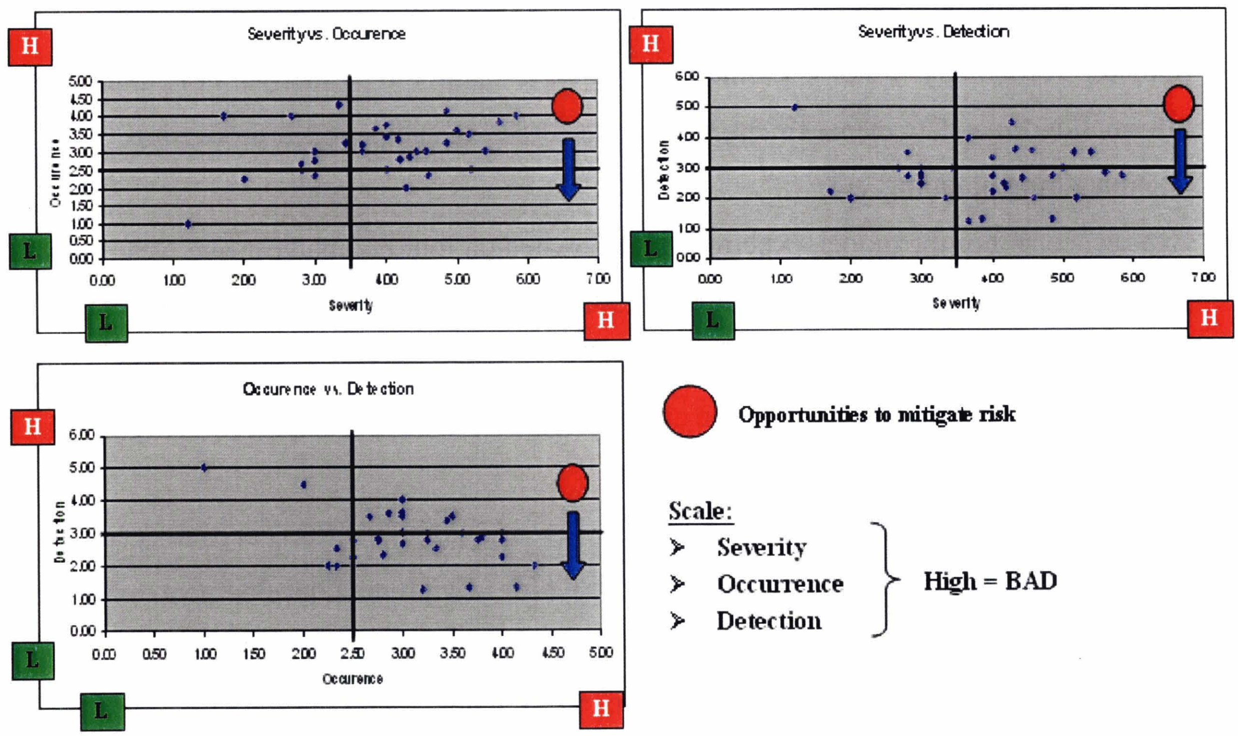


Figure 4: Comparison of Risk Factors from FMEA Analysis

The organization can use this type of analysis (shown in Figure 4) to prioritize mitigation activities and also more closely review supplier characteristics that will impact risk to PKI.

As a way to represent risks in a model, a "risk portfolio" concept was utilized, which will be discussed further in the risk model development section of the thesis. However, at the bottom of the RPN column in Table 2, the value 712.43 represents the total risk valuation of the entire risk portfolio. Therefore, weight = individual RPN/total portfolio risk valuation.

As an example, for risk factor 1 (import/export experience), 70.08 (individual RPN) ÷ 712.43 (total portfolio risk) = 0.0984. Therefore, the model will assume that risk associated with trade compliance comprises 9.84% of the total risk portfolio. The utilization of this weight factor will be described in Chapter 8.

## 4.3 Analyze

During the analyze phase of the project, the primary objective was to understand how each cost item would be calculated in the model and how each risk component would be evaluated. Each cost evaluated in the model would be calculated using data analyzed in this phase of the project. Table 4 shows the cost factors included and the data that was obtained to use in the computations.

| Cost Element | Required Data and Source |
|---|---|
| Freight | Negotiated freight rates from all carriers, by mode and service level. |
| Duty | Used a blended duty rate that will be described in the model. Rates are from the US and EU Harmonized Tariff Schedules. |
| Inventory | .Required lead times, service levels, demand variability, lead time variability, and cost of capital. |
| Material | Needed to understand demand requirements and component cost. Demand forecasts for 12-18 months were gathered and included both dependent and independent demand. Dependent demand being that demand that is associated with service sales or warranty requirements. Independent demand is the part demand to be used for the production of a finished instrument. Component cost is the quoted material cost from each supplier. |
| Tooling | A direct cost input from the model user. |
| Fuel Surcharge | To keep the surcharge rate current, a direct link to the Fed Ex website was to be used in the model so any changes to the rate would be reflected in the model immediately. Fuel rates for ground and air transport were analyzed. |

| | |
|---|---|
| Tariffs | The tariffs that were determined to be valid were a merchandise processing fee (for ocean freight) and custom clearance fees based on the import country of record. |
| Safety Stock | Utilized a performance/service level identified in the model that would allow the user to select a value between 90% and 99.9%. |
| Packaging | Required input from a supplier to provide the packaging cost for the products. May also include special packaging requirements identified by PKI. |
| Payment Terms | Provided by the supplier in the quote. Typical values may be Net 60, Net 45, etc. |
| Accessorial | Any additional charges applied to a shipment by the carrier. Examples may include refrigeration, pick-up or drop-off charges, etc. |
| Supplier Qualification | Any expenses associated with conducting site visits to qualify a new supplier. |
| Discounts | Provided by the supplier on the quote when a discount may be offered on an invoice if paid prior to the agreed upon payment terms. |
| Hazmat | A standard charge would apply if the quoted material can be classified as hazardous material. |
| Warehousing | Any charges that can be associated with sourcing alternatives that would occur within the warehouse. A primary example would be if an ocean container would be used to buy in larger quantities, additional warehouse space may be required to house the material until it is consumed. |
| One-time charges | Any relevant cost, as identified by the model user, that is not explicitly called out in the other cost factors. |

Table 4: Description of Costs from the Analyze Phase of the Project

Each of the specific calculation methods used for each cost factor will be discussed in Chapter 7.

### 4.3.1 Cost Model Analysis

For the cost development exercise, one primary area of concern was freight cost and duty cost associated with any particular sourcing decision. These costs were a significant challenge due to the many complex freight rate options that exist for the purchasing team to consider. Furthermore, selection of an accurate duty rate using the structure provided by the Unites States Government in the published Harmonized Tariff Schedule (HTS)[5] is often difficult. Despite the necessary due diligence by a supplier or purchasing agent to select a correct HTS code, ambiguous product descriptions can often be identified as the root cause of incorrect product coding. The solution to this challenge will be described in Chapter 7.

Another purpose of the analyze phase was to understand the landed cost model options required to accommodate sourcing processes in the United States, the United Kingdom, and Singapore. Other key data elements that were analyzed as a part of the cost model were as follows:

- Demand forecasts by product for all geographies;
- Part weights and dimensions;
- Financial data which included inventory carrying cost, interest rates, etc.

Further, during the analyze phase, a comprehensive list of data required from the user was developed. These data elements would need to be available from a supplier quote or request for quote (RFQ). Part of the analysis revealed that many these inputs were already a part of the quote process, but were not used collectively in the sourcing decision making process. The list of inputs is provided below.

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[5] United States International Trade Compliance Online. 2007. 10 September 2007. <http://www.usitc.gov/tata/ > and Customs Info Online. 10 September 2007 <http://www.customsinfo.com>

- Manufacturing country of origin;
- Raw material ship from country;
- Lot size;
- Shipping carton dimensions;
- Order quantity;
- Order frequency;
- Hazardous material status;
- Instrument where part is used;
- Freight mode options;
- Shipping service type;
- Freight terms;
- Unique part attributes;
- Finance terms;
- Payment discounts;
- Assist value;
- Tooling cost;
- Material cost;
- Lead time;
- Service level;
- Packaging cost.

### 4.3.2 Risk Model Analysis

After a significant amount of research, it was determined that few risk models determined risk in a quantitative manner. Specific analysis techniques such as the Analytical Network Process (ANP) allow multiple risk criterion to be compared, establishing control or a hierarchy of risks and showing how they relate to one another through pair wise comparison (Saaty 1-14). Since independence among the risk factors is not a requirement, the method can be used for processes like supplier selections. However, these models often created comparisons of risk factors, but rarely would look at risks as a portfolio, as described above. For this model, the purpose was not to determine which risks were more relevant than another, since that exercise was completed using the FMEA analysis. Rather, the intent was to understand the relative risk of a supplier against a variety of factors. Therefore, the model employs a utility-weight algorithm for analyzing risk. Granted, there is still some subjectivity associated with the process, but the algorithm attempts to do the following:

- Eliminate subjective analyses of supplier business behavior when determining risk;
- Create a mechanism that uniformly rates supplier risk;
- Produce a outcome that can be used to compare suppliers;
- Develop a method that considers changes in supplier performance over time.

The utility development process uses the concept of traditional economic utility functions where a consumer or customer ranks each alternative and their preferences to determine a priority for decision making. Then, an expected value can be computed based on a finite number of alternatives.[6] Similarly, in this model, utility is determined based on user input to how much risk

[6] Wikipedia. 2007. Wikipedia. 19 November 2007 <http://en.wikipedia.org/wiki/Utility#Utility_functions >

PKI is willing to tolerate from a supplier. The development of a utility factor required both a qualitative and quantitative approach to ensure all suppliers assessed in the tool would be represented equally, regardless of any preconceived notions about risk associated with any one particular supplier. The risk analysis is divided into three unique parts; a normalized utility scale, a supplier capability scale, and supplier input based on a newly developed questionnaire. A description of the questionnaire will be provided in Chapter 8.

**Normalized Utility Scale**

In order to assess each risk uniformly, it was necessary to develop a normalized scale for evaluation purposes. Therefore, a scale from 0 to 100 would be the basis for the utility of the risk factor. Making use of the weight factors from the portfolio and the normalized utility values allows for creation of a risk index. The risk index is calculated by multiplying the weight and utility for each factor. A maximum value is possible if the supplier has the maximum risk utility for each risk factor as determined by a global, cross-functional PKI team. In addition to the normalized utility scale, different evaluation scales were required for each factor. The variety of evaluation scales with respect to utility included linear relationships, inverse linear relationships, complex non-linear relationships, cumulative capability assessments, and simple binary evaluations. Examples of factors with each of these scales will be provided in Chapter 8.

**Supplier Capability Scaling**

Although the intent of the model is to reduce subjectivity, risk analysis, by its very nature, can be biased. However, in the model, an attempt was made to create a consistent scale for all suppliers to be evaluated against, therefore reducing individual sourcing decision subjectivity. The concept of the evaluation scale is to determine a range of acceptance associated with each risk factor. The range would be aligned with the normalized scales noted above, to allow for a risk index to be calculated. The intuition associated with each scale is as follows:

- Linear scale → lower utility = lower risk;
- Inverse linear scale → higher utility = lower risk;
- Complex non-linear scale → lower utility = lower risk;
- Binary scale → high or low risk based on binary input;
- Cumulative capability scale → Minimum capability = higher risk.

To explain further, below are examples of risk factors with linear, inverse linear and complex non-linear relationships.

*Linear Relationship Risk Factors:*

- Inventory Requirements
- Currency Volatility

*Inverse Linear Relationship Risk Factors:*

- Geopolitical Risk
- Experience (YOY growth, years in business, and commodity experience)
- Financial Strength
- FDI Investment
- New Product Development Capability (project references)

*Binary Risk Factors:*

- Strategic Supplier
- Experience (other Fortune 500 customers)
- Supplier Supply Chain Management
- Progressiveness
- Inventory Requirements
- Preferred Carrier Availability
- New Product Development Capability (formalized R&D capability)

*Cumulative Capability Risk Factors:*

- Supplier Technology
- Organization Structure
- Product Quality
- Process Quality
- Supply Chain Delays
- International Trade Import/Export Experience
- New Product Development Capability (engineering skill sets)

*Complex Relationship Risk Factors:*

- Capacity Utilization/Availability
- Business (Revenue) Represented by PKI

The specific calculation methodology associated with the utility-weight analysis process will be described in Chapter 8.

## 4.4 Design

The design phase contained the development of all aspects of the models that will be described in the Chapters 7 and 8. In addition to the actual model development, other activities included in the Design phase were as follows:

- Continued interaction with PKI sites in the UK and Singapore so the model would be inclusive of their unique sourcing requirements;
- Completed multiple case studies, leading to several iterations of the model;
- Conducted user training;
- Developed an Information Technology (IT) roll-out plan for implementation;
- Developed work instructions and technical manual for the model;
- Interacted with suppliers to get input on the risk model attributes and supplier questionnaire requirements.

The design process involved global and functional subject matter experts (SME) from across the organization. These individuals provided critical feedback and testing of the model as it was developed. The model went through several iterations to ensure that the design was robust and the interface user-friendly. Data entry processes, reporting, archiving, and data warehousing were all critical aspects of the development of the model. The original intent of the model was to make the front-end a simple data entry process that would be intuitive for the user to navigate. As a result, the model has two components; a data warehouse application and a dynamic modeling application for both cost and risk modeling. The data flow of the model is depicted in Figure 5.

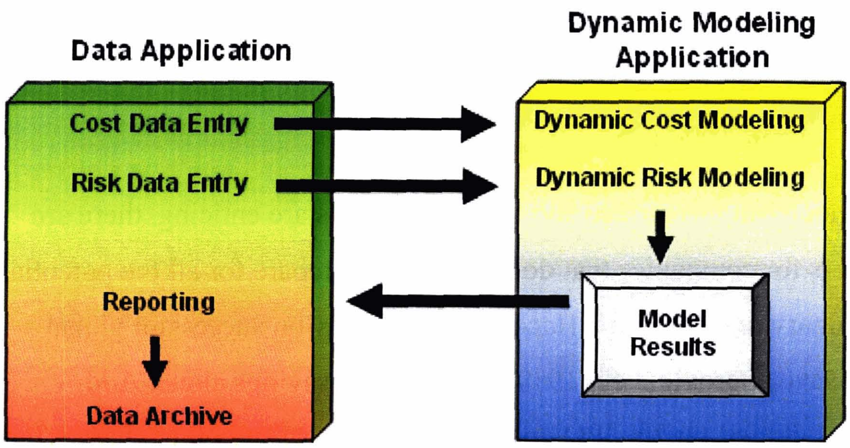


Figure 5: Model Data Flow

As noted above, two (2) additional activities that took place during the design phase were the development of detailed work instructions and a complete technical manual for the model. The work instructions were designed to walk a user through the model, and clearly articulate each necessary step to make the model work correctly. The document included visual and written instructions to ensure clarity around each step. Additionally, the work instructions provided "behind the scenes" information to inform the user how the dynamic model was using each element being entered in the data application. The technical manual was designed for the Information Technology (IT) team to use to expand the model or troubleshoot any issues a user may encounter. The document contains data flow diagrams, table structures, data sources, and model interactions. As was noted in the objectives of the project, PKI desired that the resulting model be scalable for other lines of business beyond the Life and Analytical Sciences business. These two documents facilitate that objective.

### 4.4.1 Hypothesis Identification

One of the primary purposes of the model, and specifically the design phase, was to provide more insightful cost information when considering suppliers in low-cost countries or emerging economies and prove or disprove when sourcing in low-cost countries is beneficial. According to *Purchasing.com*, "U.S. companies in greater numbers have heard—and are heeding—the siren's call to source products and parts overseas to reduce overall costs and compete more aggressively at home. A recent study by the Boston-based Aberdeen Group found that CPOs rate low-cost country sourcing (LCCS) a top priority over the next three years, and that companies plan to double their spending with offshore suppliers by 2008. The report also found that purchases from low-cost countries have average cost savings of 10-35% compared to U.S. and Western Europe suppliers.

While the LCCS road looks smooth on the surface and the cost benefits are enticing, there are potholes the size of moon craters for companies that do not properly prepare for all the potential hazards along the way. Preliminary results from a Hackett Group study on successful global sourcing show that companies save approximately 19% on parts price savings alone. Add expenses, such as shipping costs, duties, tariffs, IPO operations, inventory and other charges, and the savings dwindles to less than 17%—an important 2% difference when plotting financial targets and presenting results to the CFO. Buyers should specifically pre-screen any supplier, most of all a LCCS supplier, before entering into a contractual arrangement" (Forrest *Nine Tips*).

Using the resulting model, PKI would like to calculate when sourcing raw materials for a low volume, high mix manufacturing operation is less expensive using suppliers in low cost countries, domestically, or other global geographies. The model will show that despite an appealing material cost advantage, other cost factors are often significant enough to erode any significant savings.

## 4.5 Verify

The verify phase activities were valuable in that they created opportunities to conduct conversations on how the model would be used going forward, what processes would be in place to make sure the model was used, and how the organization would use archived data to further partner with suppliers and consolidate spend with strategic suppliers. Other activities included in the verify phase were as follows:

- Validating freight estimates with existing freight invoices;
- Conducting case studies on past sourcing opportunities;
- Utilizing current quotes for model validation and accuracy;
- Making final adjustments to the model calculations, data, and web queries;
- Conducting super-user training so they could become the trainers in the future;
- Finalizing the install process in all three global manufacturing sites;
- Rolling the model out to super-users in all geographies.

Verification activities also created opportunities to answer questions about how the model might be used in the future as the business grows and expands.

## 4.6 Chapter Summary

Using the DMADV process provided a structured approach to developing the landed cost and risk model. By using the stage-gate process, stakeholder buy-in, model attributes, and data content were validated regularly in the process. The approach also ensured continued development progress results verification throughout the project.

## Chapter 5: Organizational Assessment and Change Management

One of the key challenges of the project was overcoming the current evaluation process and metrics used to drive procurement decisions. Historically, PKI has used a metric called Purchase Price Variance (PPV), which measures the difference in quoted piece part cost and the weighted average cost from the preceding year. For example, if Supplier A is the incumbent supplier and is currently selling a component for $2.00/unit and Supplier B (new) quotes $1.00/unit for the same part, the PPV savings by going with supplier B would be $1.00/unit. Had the same cost reduction been negotiated with supplier A, the PPV savings would also be $1.00/unit. Ultimately, this metric was the driving force behind many of the actions and behaviors of the global purchasing teams. The metric itself is worthy of consideration, but should not be the only cost consideration when making a sourcing decision. In a Global Sourcing White Paper, David Horne suggests that when sourcing product domestically, PPV may be a reasonable metric since other costs may be negligible compared to material cost. However, when sourcing globally, PPV no longer provided the same gross margin improvement insight. Products with PPV savings of 40-50% would end up with 10% savings or even a higher cost when the total landed cost was considered. In fact, in some cases, products with higher material cost had lower landed costs when all factors were considered (Horne 1-3).

The challenge comes from the culture and history surrounding PPV. The metric is used for variable compensation, business unit scorecards, departmental performance reviews, and ultimately for supplier evaluations on ability to price competitively. Throughout the project, there was a significant effort to change behavior and metrics to align with the outcome of the model. These efforts took place at all levels, from senior leadership that will ultimately drive the change in metrics to the purchasing agents and sourcing team that will now have the information and data to support alternative sourcing decisions. It was critical that viewing the results of the model and using them in making sourcing decisions was not just a top-down management directive. Support from senior leaders was critical, but users of the model needed to support the cost analysis process that would result from the model.

In the following sections, using a three-lens approach developed at MIT (Ancona 12-75), organizational structures and the challenges and roadblocks that are in place to accepting the model results will be explored. In addition, other organizational observations that were made are included to demonstrate how the human relations, organization structures, and team interactions impacted the project and may impact the future adoption of the model.

## 5.1 Organization Analysis

In this section, three primary topics will be covered; organizational alignment and metrics, internal communications, and team capabilities.

First, the two primary functional areas that will work with the model directly are the Global Strategic Sourcing (GSS) team and the purchasing team. Both groups are focused on supplier relationships and establishing supplier partnerships. The purchasing teams tend to focus more on tactical procurement activities while the GSS team is driving initiatives such as supplier identification, consolidation, and partnerships. Also, the GSS and purchasing organization structures are different from site to site. It is not necessary that the organization structures align exactly, but since the model will be centralized between US, UK, and Singapore sites, the opportunity exists to leverage common data and common suppliers to reduce global material spending. Regardless of structure, both teams are critical to the success and adoption of the model. The GSS team must embrace the costing and risk analysis methodology of the model, while the purchasing teams must be committed to using the model on a regular basis to ensure supplier capabilities are accurately reflected. Furthermore, individual performance metrics should be aligned to focus on all cost components identified in the model, not just PPV. The importance of alignment becomes more significant when the model is implemented since other teams that impact operational cost (inventory, operations, logistics, etc.) are not measured by PPV.

Moreover, emphasis on gross margin and how it may be impacted by the results of the landed cost model should also be addressed. Conclusions from the model may suggest a supplier selection that sacrifices short-term margin targets established by executive leadership. Both front-line leaders and executives may have to reform thought processes on making cost decisions based on holistic cost analysis and long term relationships versus one-time material cost differences.

Second, the model will serve as a means to further communication efforts between different organizations that have an impact on the model, including logistics, trade compliance, operations, and purchasing. As the sourcing alternatives grow globally, costs identified in the model will become more significant when the majority of the suppliers are local to PKI sites. Since the total landed cost model will include costs from many functional areas, sharing the strategic goals and opportunities for each group among the teams will allow the best suppliers to be selected and ensure alignment within the organization. Additionally, by involving these support organizations, strategic supply chain opportunities identified in the model can be prioritized in a formal roadmap or project planning process.

Third, the model was developed to allow many supply alternatives to be considered. It is possible that the bandwidth of support organizations is not adequate to support more strategic supply chain analyses. Results from the model can be used in business case development to support the acquisition of capabilities needed to realize potential savings (e.g. analysts, simulation software, etc.).

Each of the points above is intended to provide a viewpoint on how the model will impact the sourcing strategies at PKI. In the following section, the current culture of the business will be reviewed. The intent was to uncover how the culture supports the adoption of a landed cost and risk model or where opportunities exist to change the culture, ensuring the model is incorporated into sourcing processes.

## 5.2 Cultural Analysis

The culture at PKI is a very collegial one with many individuals having significant tenure with the company. Since PKI has traditionally grown inorganically, the organization is very accustomed to change and adopting new processes, which was critical for the adoption of the landed cost and risk model. Despite the flexible culture, there was still a normal resistance to change. The initial responses from the group with regards to the model ranged from "this is light years ahead of anything we have had in the past" to "the model seems really complex and time intensive to use."[7]

The biggest challenge will rest with the users of the model taking ownership and investing the time necessary to fully use the model. The adoption of this model is much like any other software implementation. There is a learning curve associated with the new product. However, over time, the data population process, reporting, and analysis process becomes part of "normal" business operations. At PKI, the value of the model will be realized when strong advocates, at all levels of the organization, emerge and insist on seeing the model results for any sourcing decision. Widespread adoption of the model will also require more collaboration between operational teams than has been needed in the past. There will also likely need to be more interaction with existing or potential suppliers for data so an accurate supplier assessment can be completed. Sharing information and data with suppliers as partners will enhance the long-term value of the model. Use of the risk model on an on-going basis will drive systemic improvements for PKI and suppliers and foster improved communication, data sharing and collaboration throughout the value chain.

Inside the GSS and purchasing organizations, the teams have excellent working relationships, which should support the communication and best-practice sharing with the tool. As super-users emerge, they will be able to share their learning with the rest of the organization. These relationships will help the model adoption since there are many respected individuals able to help influence others to use the model as intended.

Another cultural challenge that may become relevant is when buyers are working with suppliers in countries that are unfamiliar. Learning customs, communication forms, subtleties, and politics will be required to conduct business efficiently around the world. The cost and risk model depend on supplier data, so it is imperative that suppliers fully understand risk evaluation questions and that model users review supplier data carefully for any discrepancies. Using the risk model as a collaborative tool with other cultures may cause initial skepticism with suppliers. However, if PKI uses the data to help develop supplier capabilities and manage data flow, the

[7] Comments came from subject matter expert interviews during the design phase of the project.

model will be viewed as a positive development tool as opposed to a mechanism for supplier admonishment.

Finally, as strong support for the model arises from global manufacturing sites, sourcing decision successes must be shared with all global manufacturing sites. Sharing the "wins" will help to drive the value of the model and change the culture to one that embraces a total landed cost view of strategic sourcing over one that values PPV savings. It is important to recognize that the wins may come from any organization represented in the model. Since the model includes input and analysis for logistics, trade compliance, finance, operations, inventory, R&D, purchasing, and IT, any of these areas may experience a positive outcome from use of the model.

## 5.3 Political Analysis

Reviewing the organization from a political perspective involves considering multiple "stakeholders." Stakeholders are defined individuals and groups who contribute important resources to an organization and depend on its success but who also have different interests and goals and bring different amounts and sources of power to bear in organizational interactions (Ancona 12-75). The consensus among the leadership team was that the project will be a tremendous benefit to the organization. It helps promote key initiatives within each business function and is needed to justify sourcing decisions in low-cost countries in a quantitative way versus making a qualitative assessment. Building on this support, there are a number of aspects of the political landscape that should be addressed to ensure adoption of the model takes place globally and accountability for executing the process is established with the correct functions.

First, the users of the model will have to be empowered to work with suppliers and develop capabilities that reduce risk and therefore, reduce cost. If sourcing analysts cannot work cooperatively with suppliers and feel free to discuss sourcing strategies (e.g. order frequency, economic order quantities, transportation alternatives, etc.), the "what-if" capability in the model will not be fully leveraged.

Second, the flow of information for cost and risk analysis will be critical to the relevance of the model output. The GSS and Purchasing teams must work closely together when using the model. As the Purchasing team experiences day to day interaction with suppliers, they must provide information to the GSS team that may impact future sourcing decisions with that supplier. There should be clear delineation between the strategic nature of the GSS teams and the tactical responsibilities of the local Purchasing teams. The two teams, along with other departments managing the costs included in the model, should provide a "check and balance" process for supplier selection.

Third, suppliers are likely to lose power with the new model. Since the entire landed cost will be considered, suppliers will no longer be able to compete on material cost alone. They will now be evaluated on organization structure, quality, financial strength, etc. which will be a new way of conducting business for PKI and many of its suppliers. Sole source providers may yield significant power until PKI can find alternative sources for materials, but if the formal risk analysis process uncovers high risk suppliers, they are now at risk of losing PKI business unless they can partner with PKI to reduce or mitigate those risks. Using the landed cost and risk models will be a paradigm shift for both PKI and the suppliers and should lead to a more rigorous supplier selection process

Finally, since one of the objectives of the project was to create a portable and expandable model that can be adopted by other PKI businesses, leaders of those businesses will have to leverage the learning and best practices demonstrated by the Life and Analytical Sciences business. Historically, there has not been significant process sharing across businesses, but initial reactions to the model were met with great enthusiasm throughout the other business segments.

## 5.4 Chapter Summary

In conclusion, significant due diligence was done to include the initial input and feedback from the more than 20 stakeholders throughout the process. Each SME opinion and feedback was heard and incorporated in the model development process. Generally, business units and functional teams gave great support for the project and believe the outcome will be a significant improvement for supplier selection in an expanding global manufacturing environment.

## Chapter 6: Model Attributes and Functionality

As an introduction to the landed cost and risk analysis models, this section will outline the technology and primary functionality of each. Specific capabilities and calculations will be discussed in Chapters 7 and 8.

The model itself was built using Microsoft (MS) Excel and MS Access applications. To allow the model to be portable and easily adapted for the Life and Analytical Sciences business and other PKI businesses, the data structure was established to simplify development, future enhancement, and to facilitate the use of a global data repository. The specific functions included in each application are shown in Figure 6.

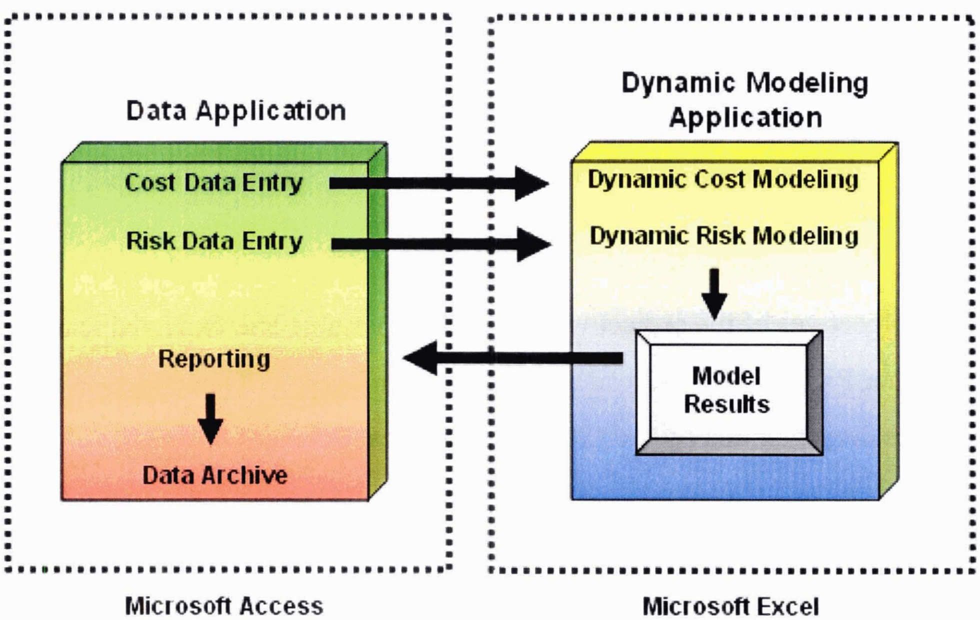


Figure 6: Processes Included in Multiple Applications

The data flow diagram shown in Figure 7 provides an interpretation of how data is entered, stored, retrieved, utilized, and reported.

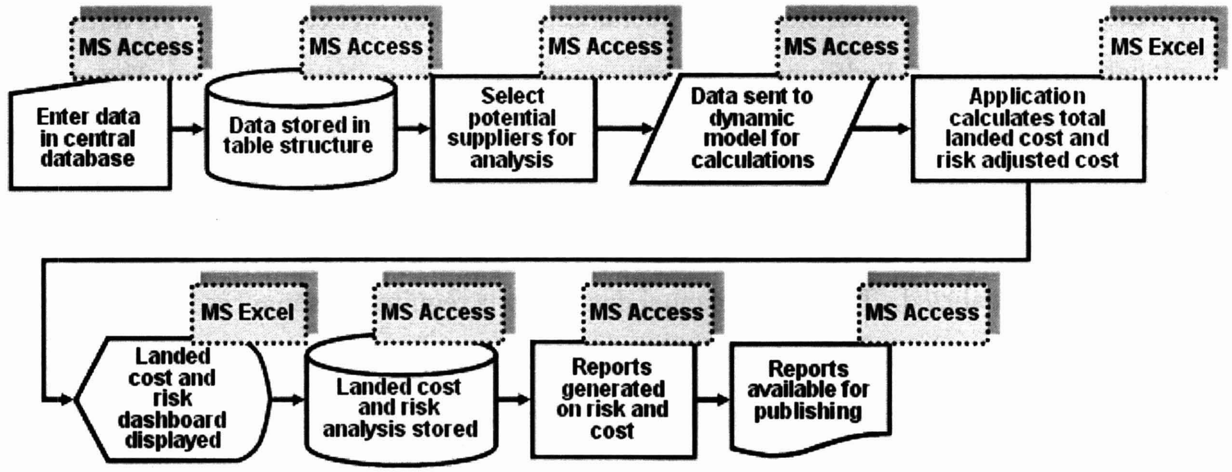


Figure 7: Data Flow between Applications

During the design and development of the model, a great deal of potential functionality was discussed and reviewed. Through many iterations and revisions, the core functionality is described below.

## 6.1 Landed Cost Model Features and Functionality

The primary functionality of the landed cost model is to incorporate all of the cost elements defined in previous chapters. The results of the analysis are described within the following features:

- *Computes total costs over a user-defined evaluation period.* The user of the model may choose any period of evaluation between one (1) and five (5) years. These periods were selected based on typical supplier contract terms.
- *Provides the NPV of costs beyond year one.* Since the model allows for up to five (5) years of evaluation, the NPV of the costs beyond year one are discounted at a specified corporate interest rate.
- *Allows for one-time cost inclusion in the model.* Cost factors were limited to those listed in the Measure phase, but to allow maximum flexibility in the model, an option exists for the user to include any other unique costs that are relevant to the specific analysis they are conducting.
- *Utilizes data from real-time sources, user-inputs, and calculations.* The model is dynamic in many ways, one of which is that data sources are taken directly from credible web sources and updated in the model on a real-time basis. An example is the current fuel surcharge

percentage for ground or air shipments fluctuates based on market conditions. As a result, a global shipper such as FedEx publishes new surcharge rates on a regular basis.[8] The model uses these rates for all shipments. Recognizing that other carriers may have slightly different rates, it was accepted that FedEx rates serve as a proxy for any other rate as they would likely be within an acceptable range. A significant amount of data also depends on submitted quotes being analyzed. Therefore, manual data entry is required in some cases. The archive capability of the model allows data to be reused and modified for future related analyses.

- *Allows complex calculations to be transparent to the user.* One of the design requirements was to shield the user from the complexity of calculations that are taking place in the dynamic model. Consequently, much of the user input and navigation is done through simple a graphical user interface (GUI) design in MS Access. The typical user will not have a need to explore the complex calculations being done in the background (MS Excel), but documentation provided allows a user to understand the data manipulation performed to calculate the landed cost.
- *Includes many defaulted values to simplify data entry.* To strike a balance between completeness of data and ease of data entry, many entry points have values that have been defaulted or are provided in drop down menus to assist with the standardization of the data entry process. Subject matter experts help to establish default values throughout the model, but each can be changed based on the specific parameters of the quote. An example of a defaulted value is the payment terms from a supplier. A standard of Net 60 (payment within 60 days of receipt of invoice) is used quite frequently and therefore is the default value seen by the user.

As described earlier, another of the primary design objectives of the model was to allow a wide range of scenarios to be considered in the model. Examples of scenarios may include

1) Compare an incumbent supplier with new supplier(s);
2) Test multiple new suppliers;
3) Evaluate bundled quotes for multiple products from multiple suppliers.

[8] FedEx Online. 2008. FedEx. 3 December 2007. <http://www.fedex.com/us/services/fuelsurcharge.html>. Although surcharges may vary by carrier, FedEx rates are used as a proxy for other carriers. Given the global service network of FedEx, their rate is representative of the industry.

To accomplish these objectives, the model needed to be extremely flexible, while requiring core values to produce a meaningful landed cost. As a result, there is a significant amount of functionality and capability with the model. Each of the following sections briefly describes the key capabilities which are included in the model.

**Suppliers** – Up to three (3) suppliers may be evaluated during any run or scenario of the model. The decision to include three suppliers was based on historical evidence of how many suppliers would generally be considered for any one sourcing decision. Going forward, a scenario will be defined as a unique supplier and the multiple parameter variations that may exist for that supplier.

**Transportation Mode** – For each scenario, the model will allow the user to compare and contrast up to three (3) transportation modes. The modes that are allowable for the user to consider include air, ground, and ocean.

**Freight Service** – Depending on the location of the user (US, UK, or Singapore), preferred carriers have negotiated freight services (e.g. Priority, Overnight, Standard, Freight, etc.). Tables representing each of the valid service types for each freight mode can be selected by the user. Often, there may be a significant cost trade-off between Priority and Standard freight classes, but very little difference in lead time. Using the parameters, the user can analyze the impact of mode and service together to get a better estimate of landed cost. It is important to remember, however, that this model is not an optimization model. The model attempts to model costs based on defined criteria, but does not independently assess all possible parameter variations and optimize on least cost, shortest lead time, or any other factor.

**Lead Time** – Working with the logistics teams and suppliers, an estimate of lead time is entered based on freight mode. The lead time, demand variability and service level are used in the model to understand inventory carrying cost associated with each scenario.

**Lot Size and Packaging** – It is feasible that different lot sizes would be used depending on the mode of transportation or even within the same mode. This parameter will allow the user to provide input on the lot size to understand the impact on freight cost.

**Order Frequency** – Similar to packaging, the order frequency may vary based on lead times, lot size, and transportation mode. The user will be asked to input the order frequency for each possible scenario.

**Reporting and Archiving** – One of the key requirements for the model was to provide archive and reporting capability for any scenarios entered in the model. Therefore, since the model uses a relational database (MS Access), each scenario is stored, using a primary identifier that is unique to that scenario. The result is the ability to recover, reuse, and analyze past quotes and quote elements. Archiving also allows current or past quote analyses to be reported and documented for use with internal reviews, supplier scorecards, or strategy execution reviews Figure 8 depicts the functionality described above.

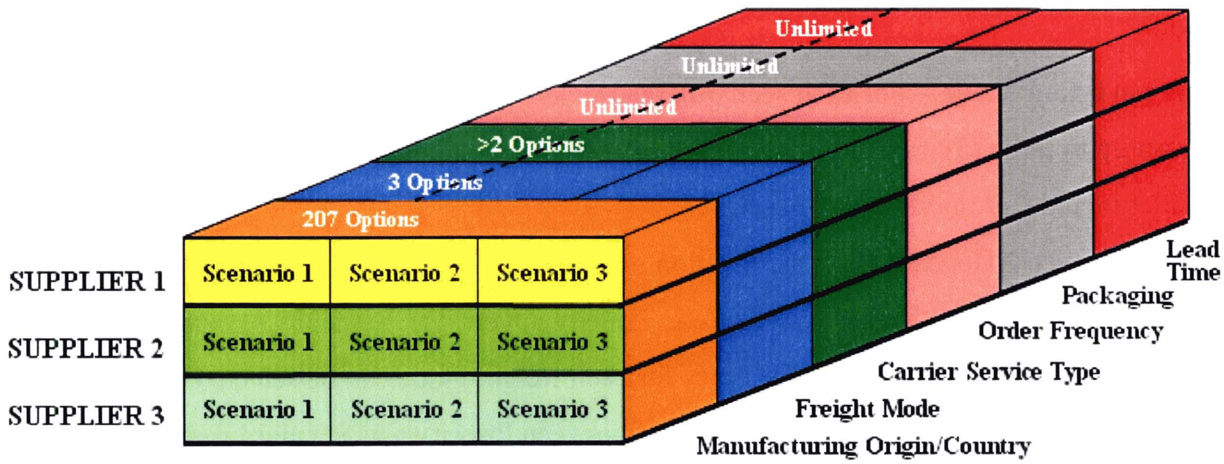


Figure 8: Landed Cost Model Functionality Matrix

To summarize, there is significant flexibility within the cost model to analyze a range of scenarios from simple scenarios with few parameters to significantly complex scenarios that have many variable alternatives. The "what-if" capability of the model is unique in that the user can assess multiple alternatives at one time to understand the cost trade-offs of freight, inventory, material spending, trade compliance, or any other cost that is included in the model. As shown in the figure below, the model allows the user community to understand how multi-mode sourcing may be used to lower the total landed cost. Based on the demand profile of a particular part or assembly, it may be feasible to use different modes of transportation for predictable demand versus the variable demand. Figure 9 depicts an example, where due to long lead times and/or lower cost, a lower cost freight solution may be selected (e.g. ocean or ground) for predictable demand. However, due to the potential higher cost of air freight, air may be utilized only for uncertain or variable demand.

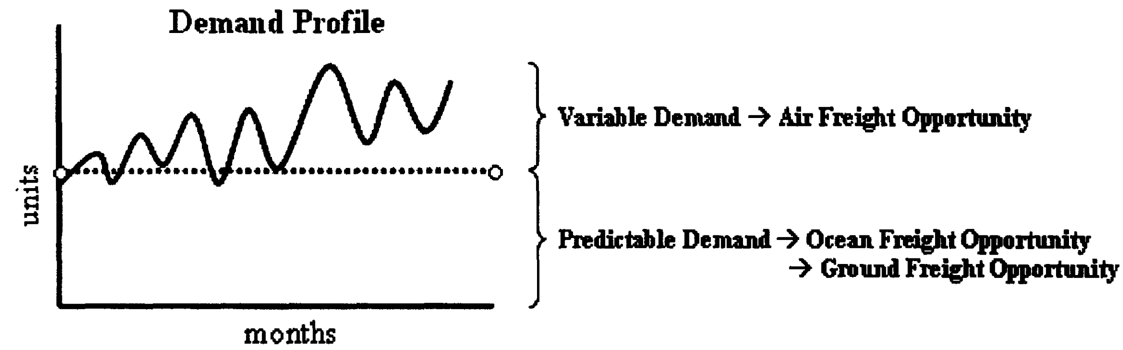


Figure 9: Demand Analysis Using the Landed Cost Model

As previously stated, there is a strong desire in the manufacturing organizations to drive sourcing and value added capability to low-cost countries, where the material cost may be significantly cheaper than local suppliers. The model will allow the user to understand where or if an inflection point exits between lower material cost and higher transportation and inventory cost (as shown in Figure 10), which can be used in negotiations with suppliers.

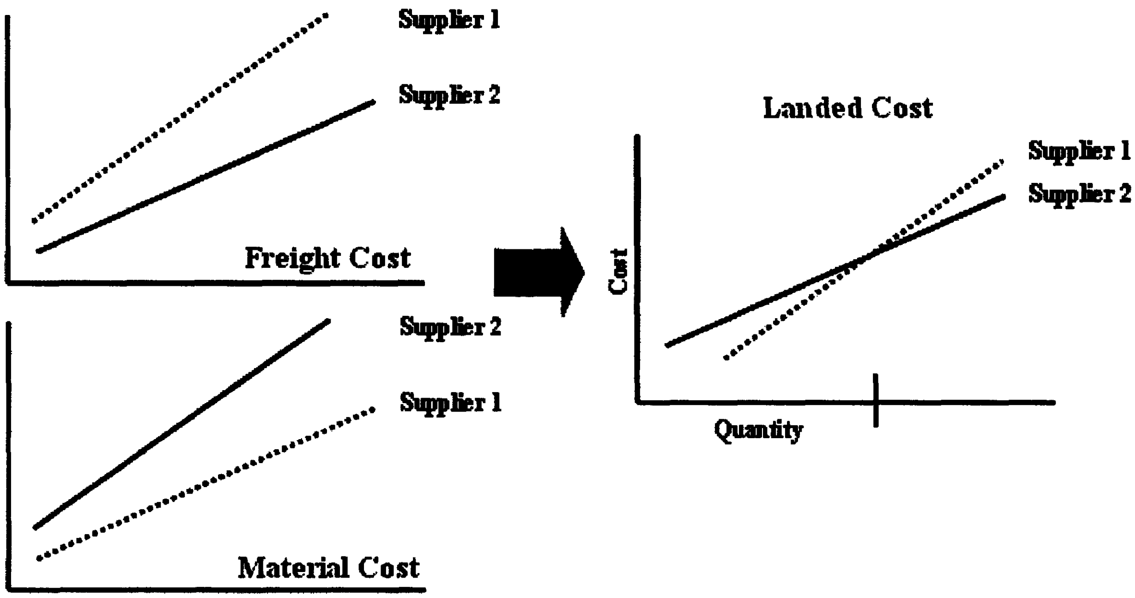


Figure 10: Cost Inflection Point Analysis

## 6.2 Risk Analysis Model Features and Functionality

The risk analysis model is intended to provide an overall assessment and uncover the potential risks that may arise in conducting business with the supplier. Using the utility-weight process, the end result of the analysis is a computed risk index for a given supplier. This risk index allows multiple suppliers to be compared using a common set of analysis characteristics.

The 19 risk factors that were described in the Design phase section make up the entire risk portfolio for a supplier. All suppliers will have a certain amount of inherent risk, but balancing the risks across many factors is essential to ensuring continuity of supply. Figure 11 shows the entire risk portfolio and the contribution each category makes to overall supplier risk.

| | |
|---|---|
| (1) Purchasing/Organizational | Geo-Political risk |
| | Capacity utilization |
| | Strategic supplier |
| | Supplier business represented by PKI |
| | Supplier technology |
| | Experience with product |
| | Supplier organization structure |
| | Supplier supply chain management |
| | Supplier progressiveness |
| (2) Inventory/Quality | Product quality |
| | Inventory requirements |
| | Process quality |
| (3) Finance | Financial strength |
| | Currency volatility |
| | FDI investment |
| (4) Logistics | Preferred carrier availability |
| | Supply chain delays |
| (5) Trade Compliance | Import/Export experience |
| (6) R&D | New product development capability |

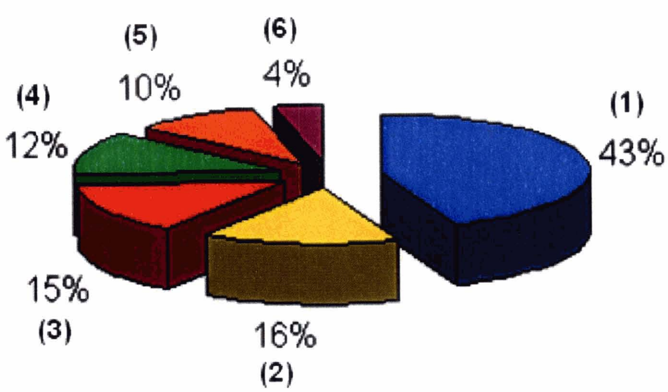


Figure 11: Risk Portfolio

By considering the entire portfolio and the resulting risk index, risk concentration can be understood and appropriate mitigation plans put in place. In addition to the overall risk index, the model also calculates individual risk indices by factor (e.g. product quality) and category (e.g. inventory/quality). The level of detail of the assessment is valuable because it allows the ability to analyze the contribution each factor makes to the overall index. Therefore, the model will allow a user to understand if the overall risk index comes from one or two heavily weighted factors or from many lower weighted factors.

For example, if a supplier had the maximum risk assigned for the top three weighted factors in the portfolio (Table 2) and had no risk in the other factors, the final risk index, using the utility-weight process, would be (100*0.0984) + (100*0.0796) + (100*0.0693) = 24.73. However, if the supplier had the highest level of risk possible for the factors that are weighted lower, in comparison (Figure 12), the following risk index would result.

| | Category | Risk | Severity | Occurrence | Detection | RPN | Weight |
|---|---|---|---|---|---|---|---|
| 13 | Purch. / Organizational | Limited experience and incumbency | 3.55 | 2.89 | 3.00 | 30.73 | 4.31% |
| 14 | Purch. / Organizational | Supplier organization structure | 3.00 | 4.33 | 2.33 | 30.33 | 4.26% |
| 15 | R&D | New product development capability | 4.20 | 2.80 | 2.33 | 27.44 | 3.85% |
| 16 | Purch. / Organizational | Supplier supply chain management | 3.58 | 3.14 | 2.20 | 24.78 | 3.48% |
| 17 | Inventory / Quality | Process quality | 3.50 | 2.55 | 2.67 | 23.76 | 3.33% |
| 18 | Purch. / Organizational | Supplier progressiveness | 2.89 | 2.50 | 2.71 | 19.60 | 2.75% |
| 19 | Finance | FDI investment | 3.67 | 3.20 | 1.25 | 14.67 | 2.06% |

Figure 12: FMEA Results/Portfolio Weight

Risk index = (100*0.0431) + (100*0.0426) + (100*0.0385) + (100*0.0348) + (100*0.333) + (100*0.0275) + (100*0.206) = 24.04.

When the risk indices of the two suppliers were evaluated, 24.73 and 24.04 would appear to be very comparable and the difference of 0.69 may seem insignificant. However, since the weight factors applied in the FMEA study are indicative of the potential impact the risk would have on the business, knowing that the index is comprised of the top three risks versus the bottom seven may lead to different conclusions and mitigation activities. Therefore, the capability to provide multiple levels of risk comparison for a supplier provides significant value for the user. In summary, the model provides a hierarchy of results, starting with the overall supplier risk index, proceeding to an index by category, and concluding with the index associated with each factor.

The model displays each of these levels of information in the form of a dashboard, which will be discussed in Chapter 8.

The final function of the risk index is to work in tandem with the total landed cost for the development of a risk-adjusted cost. The purpose of the risk-adjusted cost is to provide an estimate of the true cost of doing business with a supplier based on risk evaluation. At the outset of the project, many cost components were identified that could not be quantified at the time of supplier selection. Therefore, a risk factor was used to assess how much of an impact that "unknown" cost would have on the business during the contractual period chosen for evaluation. To provide examples of what the risk-adjusted cost considers or may represent, Appendix 3 provides insight into the types of costs that may be incurred should a supply chain interruption occur. The methodology used to develop the risk adjusted cost is a two-phase process. Phase one of the process is executing the model. Phase two requires a period of cost tracking that will be described further in the following sections.

### 6.2.1 Phase I: Risk-Adjusted Cost Development

Using the cost categories identified previously (logistics, trade compliance, inventory, purchasing, and finance) and the corresponding risk indices by category, a risk-adjusted cost is calculated. The calculation requires establishing correlation between cost and risk categories, which are shown in Figure 13.

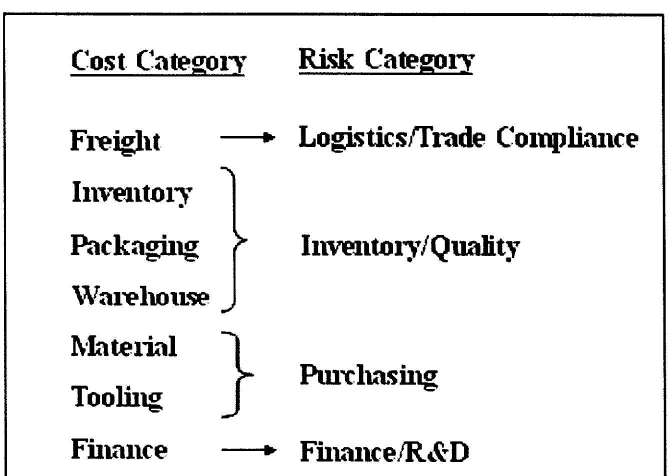


Figure 13: Cost and Corresponding Risk Category

At the outset of adopting the model, there will be very little data stored to understand historical risk indices or risk related costs for particular commodities. For example, there is no basis to understand that the typical risk index associated with a supplier who is providing cables is 30 (on a normalized scale of 1 to 100 and using the utility-weight algorithm). Additionally, there may be no historical tracking of cost that is attributed to risk factors. Specifically, if the supplier contributed to two stockouts, a rework effort on 10,000 units and required 10 shipments to be expedited over the course of a year, the cost of these efforts may not have been captured or tracked. However, it can be noted that these costs would have been represented in the risk-adjusted cost due to the definitions of what each risk factor was designed to cover. Since the actual cost associated with a risk index is not available currently, the method described below was used as an indicator or a proxy for potential cost. To calculate the risk-adjusted cost for a supplier, the landed cost by category and the risk index by category are used with the risk index becoming a multiplier of cost. Figure 14 shows an example of how the risk-adjusted cost is calculated. The numbers provided in the example are for demonstration purposes and do not represent any specific supplier analysis.

**Risk-Adjusted Cost Calculations**

| Risk Category | Computed Risk Index |
|---|---|
| Logistics/Trade Compliance | 11.3 |
| Inventory/Quality | 9.1 |
| Purchasing/Organization | 12.7 |
| Finance/R&D | 3.2 |
| Total Risk Index | 36.3 |

Adjustment factor = 11.3%
Adjustment factor = 9.1%
Adjustment factor = 12.7%
Adjustment factor = 3.2%

| Cost Category | Landed Cost (USD) |
|---|---|
| Freight | $200,000 |
| Inventory Carrying Cost | $18,000 |
| Packaging | $5,000 |
| Warehousing | $10,000 |
| Material | $650,000 |
| Tooling | $30,000 |
| Finance | $2,500 |
| Total Landed Cost | $915,500 |

$200,000 * 1.113 = $222,600
$33,000 * 1.091 = $36,000
$680,000 * 1.127 = $766,360
$2,500 * 1.032 = $2,600

**Total Risk-Adjusted Cost = $1,027,560**

**Cost associated with supplier risk assessment = $1,027,560 - $915,500 = $112,060**

Figure 14: Calculating Risk-Adjusted Cost

From the example above, the risk-adjusted cost is closely tied to the magnitude of the landed cost and the corresponding risk factor. This is by design such that in order to closely approximate the risk-adjusted cost, those costs that are the highest and carry a significant risk would drive a much higher landed cost. Conversely, a low cost category, even with high risk, would not likely result in a significant cost impact to the organization. It can also be noted that the purchasing/organization risk category has the highest risk and when coupled with the landed cost, which is also the highest cost, drives the most significant risk based cost increase. The intent of providing this perspective on cost is to facilitate the investigation of risk factors that are most likely to generate cost to the organization. The results would likely lead the decision maker to investigate the factors that make up the purchasing/organization risk category. After investigating, PKI may choose work with the supplier to mitigate, reduce, or eliminate the risk factors for both organizations.

### 6.2.2 Phase II: The Efficient Risk Frontier

The current model contains a subjective approximation of cost relative to a risk index. However, the model was built to facilitate more specific risk based cost tracking. Within the model, each potential supplier will have a risk profile. It is possible that a supplier provide several types of parts to PKI (see below for a list of part types), which would result in the supplier having up to four risk profiles in the model, one for each part category. This risk profile will contain the capabilities and skills that have been researched and/or provided by the supplier themselves and validated by PKI. Recall, these inputs are used directly in the model to compute the risk indices by supplier, by category, and by factor. To further facilitate accurately estimating the cost of risk, the model establishes four part categories; high-level assembly (HLA), Custom Component (CC), Original Equipment Manufacturer part (OEM), or a Standard Part (STD). Each part being sourced would be identified by one of these specific categories. Since the model can be expanded, additional categories can be defined in the future as more granular cost estimates are desired. Nonetheless, these four initial categories provide the opportunity to understand how risk factors can have different impact on an organization, depending on the type of part being sourced. For example, a supplier that provides consumable materials (e.g. nuts, washers, plastics, etc.) may have a different level of risk assuming that alternative suppliers are available, albeit at a potentially higher price. Conversely, a supplier that is contracted to provide a complex

HLA can have a much greater impact on the organization (i.e. operational shutdown, cost, etc.) should an issue with material supportability arise and another supplier cannot readily ramp up to meet demand. It is for these reasons that risk profiles should be reflective of unique part category.

After the risk profiles are created and established, the organization must create a process for capturing those costs that are attributable to risk (defined in Appendix 3). The costs should be as clearly defined as possible to understand the "cost of doing business" with a supplier that is above and beyond the anticipated landed cost. The gathering of the costs associated with risk will allow for a more systematic risk premium to be established in the future. A risk premium can be defined as the additional cost that a company is willing to pay based on the risk index of the supplier. This concept is similar to a finance risk premium, which is defined as the difference between the return on the market and the interest rate or risk free ($r_m - r_f$) (Brealey, Myers, and Allen 188) investment. The assumption is that every supplier will have some risk, so the lowest level risk supplier becomes the "risk-free" supplier. Therefore, over time, for each part type, a supplier risk curve could be established using the risk index and cost per unit being sourced. The primary variable that is likely to drive differences in cost per unit is the volume of the purchase. This variable would need to be normalized for each data point to ensure that the curve that is formed is representative of what costs PKI would expect to experience from future suppliers. Intuitively, the curve shows that the higher the risk of the supplier, the lower the cost would need to be to select that supplier. Furthermore, if a supplier has very low risk, it may be desirable to pay more for the products from that supplier. Figure 15 and Figure 16 show how the concept of an efficient supplier frontier parallels that of an efficient investment frontier. Additionally, using portfolio theory suggests each risk factor may have a beta, or can be correlated and fluctuate based on conditions that exist in global supply chains (Brealey, Myers, and Allen 191).

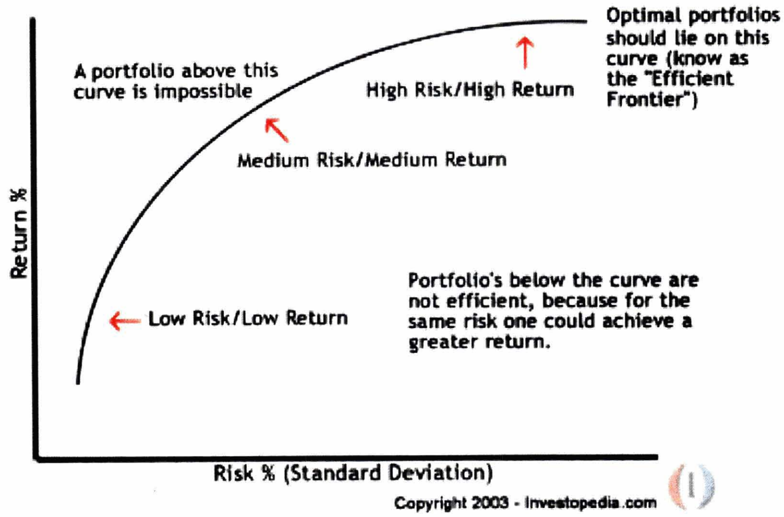


Figure 15: Efficient Frontier[9]

As defined by Markowitz, the optimal portfolio is one that produces the optimal return for the least risk possible and produces an optimal portfolio for an expected return (77-91). Similarly, an efficient supplier frontier could be established over time, for a product category. By using historical landed cost values and risk indices, a curve could be established to understand an expected level of risk that would be associated with a determined cost per part. Therefore, when PKI initiates a new quote for a commodity or part type which has been quoted in the past, any supplier cost and risk index intersection that are not close to a defined curve would be investigated further and/or may be considered an outlier.

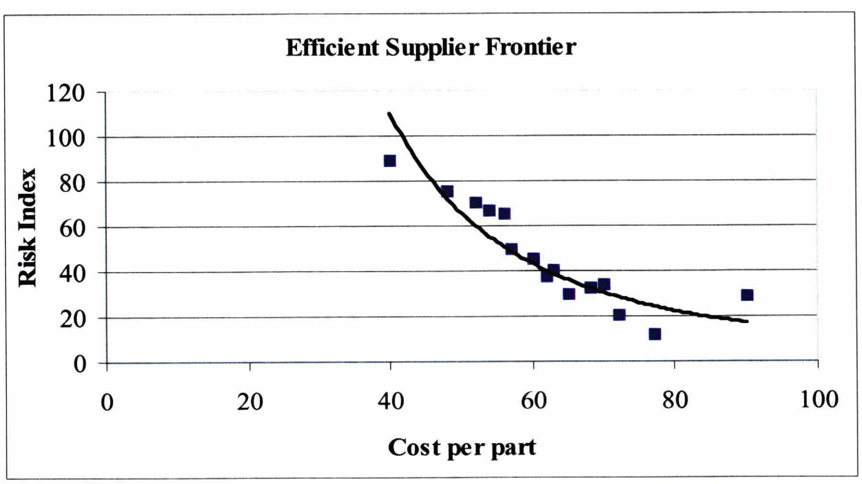


Figure 16: Efficient Supplier Frontier

[9] Investopedia Online. Investopedia. 9 April 2008. <http://www.investopedia.com/terms/e/efficientfrontier.asp. >

Capturing expedited shipment cost, overtime due to a part shortage, rework cost, labor associated with coordinating shipments with suppliers, etc. and using an activity based costing approach would allow PKI to verify that the model is accurately predicting the risk-adjusted cost. Based on the analysis, modifications to the model and the efficient supplier frontier can be made to more accurately reflect the actual risk premium that PKI is willing to pay for a particular part type.

In addition to understanding the risk frontier, the results of the cost-risk trade-off and part type can also be used to help identify the number of sources that should be considered. Often times, organizations are faced with the decision to single source, dual source, or multi-source a particular part. It may also be the case that only one provider is willing to undertake the business, therefore, sole sourcing is the only alternative. Regardless, developing a decision matrix can be established to give guidance to the sourcing strategy.

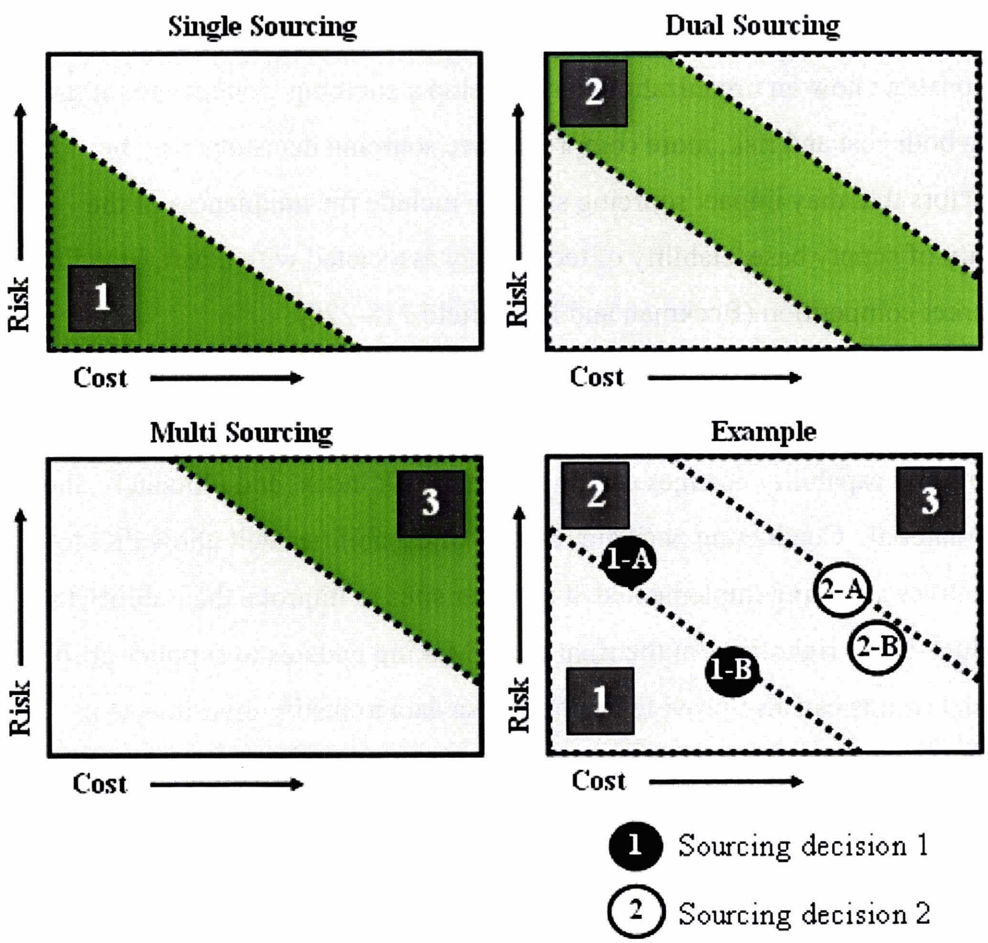


Figure 17: Sourcing Strategy Alternatives Using Cost and Risk Index

Generically, as cost and/or risk increase, additional sources may be considered to mitigate risk with one supplier or to maintain price competition between suppliers. As shown in Figure 17, there are three "regions" in the cost/risk space. The regional boundaries may differ by industry, part type, commodity, etc. but provide insight for sourcing decisions. For any situation, the best case is to have suppliers that are low cost and low risk, with "low" being a relative term based on the criteria above. However, based on where a supplier risk index and cost intersect, different sourcing decisions may be considered. For comparable suppliers in region 1, single sourcing may be acceptable. Similarly, suppliers being compared for a contract that fall in region 2 or 3, dual or multi sourcing alternatives should be considered. Theoretically, as cost and risk increase, more suppliers may be considered to enhance price competition, mitigate risk, and ensure continuity of supply. Figure 17 shows and example for two independent sourcing analyses. For sourcing decision 1, cost vs. risk index for the supplier and product relationship may lead the organization to consider a single source model. Alternatively, sourcing decision 2 may lead the organization to search out two suppliers that are capable of delivering the required product. These examples demonstrate how an organization may develop a sourcing strategy, and illustrate that by understanding both cost and risk, more comprehensive sourcing decisions may be considered. Other factors that may impact sourcing strategy include the uniqueness of the sourced part, reliability of supply base, stability of technology associated with a part, branding implications, and market competition (Beckman and Rosenfield 218-220).

One of the most useful concepts associated with the risk model is the ability to understand how supplier improvements and capability changes can impact their risk index, and ultimately, the risk-adjusted cost of material. Conducting periodic reviews of capabilities will allow PKI to understand what initiatives are being implemented at supplier sites to improve their ability to deliver the right product, at the right time, at the right cost. Making updates to supplier profiles and reevaluating model results can also provide business case data to justify investments in supplier development.

## 6.3 Chapter Summary

In conclusion, the primary functionality of the models is to provide maximum flexibility to users in constructing simple or complex supplier comparisons. By providing many parameters which can be changed to reflect an existing process or to compare "what-if" scenarios, the model will ultimately help in making sourcing decisions on a comprehensive cost basis. Similarly, by coupling the risk analysis with landed cost, the result is a unique view of the actual cost associated with doing business in a global economy. The diverse risk factors provide insight to numerous aspects of a supplier's business, all of which are critical when making sourcing decisions. Utilizing the models will help PKI select strategic suppliers and achieve sourcing benefits that include the following:

- reduced supplier management costs;
- increased ability to coordinate product development activities;
- improved ability to evaluate suppliers on many cost factors and capability indicators;
- increased ability to capitalize on supplier value-added capabilities by sourcing;
- assemblies versus components;
- enhanced supplier performance management (Beckman and Rosenfield 218-220).

# Chapter 7: Landed Cost Model Development

In the next two chapters, the final model architecture and calculation methodologies will be discussed. Also, data requirements and sources utilized in the model will be shown to further articulate the dynamic nature and capabilities of the model. The first steps required in executing the cost model are related to navigating the application. There are a series of steps that must be completed to ensure the data is properly entered for the necessary calculations to be executed. When the user opens the application, a "main menu" screen will appear, as shown in Figure 18.

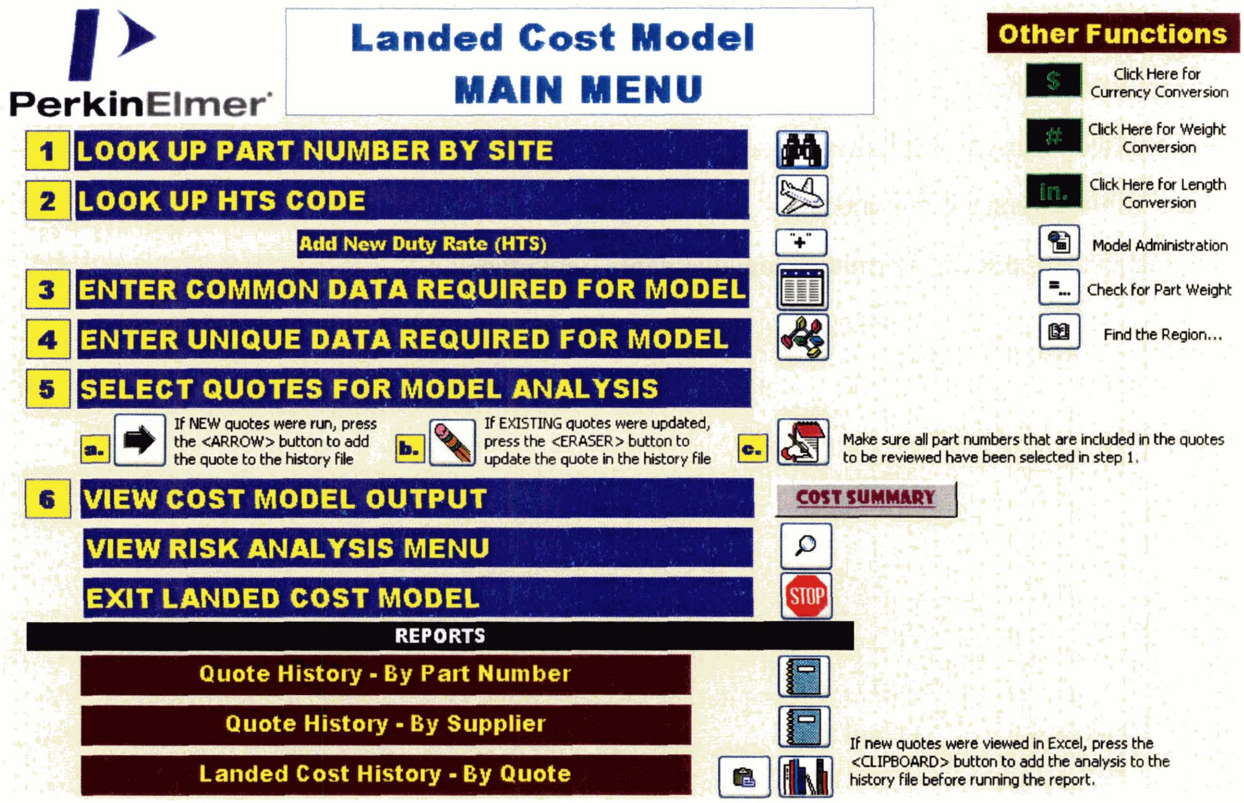


Figure 18: Landed Cost Main Menu

## 7.1 Data Entry

As the main menu indicates, there are six primary steps that the user must go through to complete the data entry process. Each step is described below, along with the primary use for the data entered.

**Step 1:**

The prompts in this step request the user provide up to three specific part numbers that will be analyzed in the quote. It is important to note, within the application is a dataset that contains 16 months of demand forecast for approximately 20,000 parts, specific to three global manufacturing sites. Also, PKI uses SAP for its forecasting functions, so the dataset utilized is taken directly from an SAP generated flat file. The demand forecasts include both dependent (parts to be used for production) and independent demand (parts that can be sold individually for warranty repair or service) to more accurately represent the true picture of demand that will be sourced to a supplier. When the user enters the part number(s), the application begins calculating the annual demand requirement as well as the standard deviation of the monthly forecast. This standard deviation will be used for inventory safety stock calculations.

**Step 2:**

In order to accurately calculate the tariff that will be charged to import a raw material, the user must provide information on the correct Harmonized Tariff Schedule (HTS) duty rate. The HTS comprises a hierarchical structure for describing all goods in trade for duty, quota, and statistical purposes. This structure is based upon the international Harmonized Commodity Description and Coding System (HS), administered by the World Customs Organization in Brussels; the 4- and 6-digit HS product categories are subdivided into 8-digit unique U.S. rate lines and 10-digit non-legal statistical reporting categories.[10] This model contains HTS codes for the US and the EU. Singapore does not charge an import tariff and thus, no code is required. After reviewing the HTS code tables, it was apparent that the process to select a correct code is extremely difficult.[11] There are approximately 16,000 HTS codes in existence and many duty rates may change from year to year. For the purposes of the landed cost model, it was not necessary to select the exact HTS code to get an accurate tariff estimate for the cost. However, it was critical that the model user have an efficient way to determine a duty rate correctly. There are three primary issues with selecting the correct HTS code:

1. choosing a description that closely represented the part;
2. deciding on a duty rate if multiple descriptions appeared accurate;
3. understanding the complexities of parts, assemblies, and subassemblies required to interpret the HTS tables.

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[10] United States International Trade Compliance Online. 2007. 10 September 2007. <http://www.usitc.gov/tata/ > and Customs Info Online. 10 September 2007 <http://www.customsinfo.com>

[11] Based on interviews with customers, Trade Compliance representatives, and Purchasing agents, all agreed that the table and description structure is often vague and difficult to interpret.

As a result of these challenges, an abbreviated process was developed for the model. After reviewing all HTS code chapters that were applicable to PKI products, the range of possible tariff rates that could be selected was determined. From these ranges, the average of the HTS rates and the standard deviation of the range were calculated. Table 5 illustrates the outcome of the process.

| High Level Com Code | Detail Com Code | Description | HTS Start | # of Choices | Duties | | | | | Average | Std. Dev | Duty Rate | As Percentage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chemicals | Isotopes | Radioactive Material | 28444 | 3 | FREE | | | | | | | 0 | 0 |
| Chemicals | Standards/Chemicals | Lubrication | 34039 | 3 | 6 | 6.5 | 6.5 | | | 6.333333 | 0.288675 | 6.333333333 | 0.063333333 |
| General | Ceramics | Ceramics | 69091950 | 9 | 4 | | | | | | | 4 | 0.04 |
| Glass | Quartz glass | Fused Quartz and Syringes | 70171 | 2 | 4.6 | | | | | | | 4.6 | 0.046 |
| Metal | Other Metals | Precious Metals - Gold, Silver | 71 | | FREE | | | | | | | 0 | 0 |
| Metal | Machine (TurnMill) | Machined Parts - Iron or Steel | 72 | | FREE | | | | | | | 0 | 0 |
| Metal | Sheet Metal | Sheet Metal - Iron or Steel | 72 | | FREE | | | | | | | 0 | 0 |
| Metal | Machine (TurnMill) | Iron or Steel Tubes and Pipes | 73049 | 4 | FREE | | | | | | | 0 | 0 |
| Metal | Machine (TurnMill) | Iron or Steel Tube and Pipe Fi | 7307 | MANY | 4.8 | 5.6 | 6.2 | 6.2 | 5 | 5.56 | 0.654217 | 5.56 | 0.0556 |
| Metal | Hardware | Misc. Screws and Bolts | 73181 | | 6.2 | 8.5 | 5.7 | | | 6.8 | 1.493318 | 6.8 | 0.068 |
| Metal | Hardware | Self-tapping Screws | 731814 | 6 | 6.2 | 8.6 | | | | 7.4 | 1.697056 | 7.4 | 0.074 |

Table 5: HTS Code Consolidation

The goal of the exercise was to determine a blended duty rate that would closely approximate the actual duty rates for a number of different HTS codes. The target level of accuracy was to obtain a standard deviation, σ, of <=1%. Three examples from Table 5 will show the process.

Example 1: For "lubricants" (which are in chapter 34 of the HTS manual), there were three possible 10-digit HTS codes that may be used for PKI parts. The possible duty rates were 6%, 6.5%, and 6.5%. Therefore, the average duty rate is 6.333% with σ = 0.28%. The result is the model would use a blended duty rate of 6.33% for all lubricants.

Example 2: For "misc. screws and nuts", there were also three viable 10-digit HTS codes. In this case, the blended, or average, duty rate was 6.8% with σ = 1.49%. Since σ > 1.0%, this high level HTS category would be broken into further divisions to achieve the σ goal.

Example 3: For "iron or steel tube and pipe" there were numerous different codes that could have been chosen by a purchasing agent with duty rates ranging from 4.8% to 6.2% and σ = 0.65%. Therefore, this grouping was acceptable and consolidated many possible HTS code choices to one simple choice called iron or steel tube and pipe. The result of this activity was the consolidation of approximately 16,000 HTS codes to approximately 100 HTS categories. This simplification process was instrumental in calculating tariff charges, allowing the user to select from a simple list of choices that are intuitive, match the corporate commodity code naming convention, and are cross-referenced with a PKI commodity shortcut classification.

**Step 3:**

Steps 3 and 4 consist of manual data entry needed for the calculation process. The data entry process was divided into two parts; common data and unique data. Common data will be covered in step 3 while the unique data entry will be covered in step 4.

Common data is the set of information that will be consistent for all suppliers being compared in the model. Figure 19 shows the GUI of the entry screen.

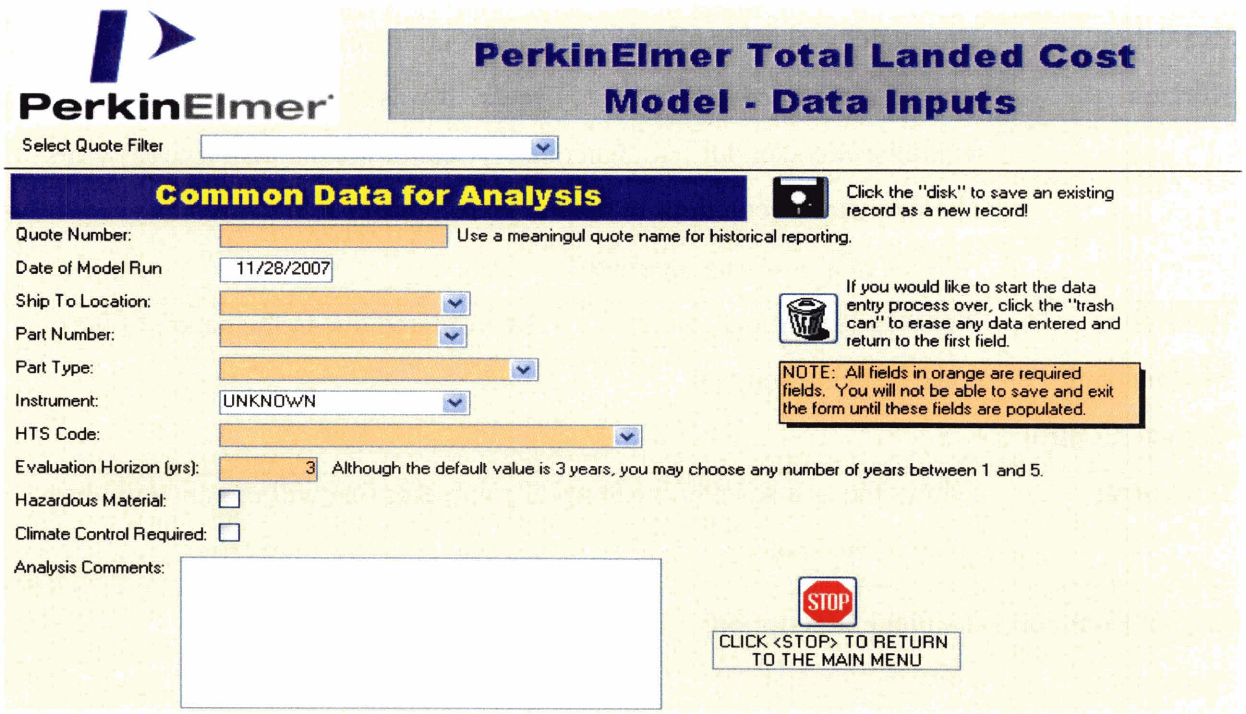



Figure 19: Common Data Entry Screen

Each field in Figure 19 is described in Table 6 below.

| ***Field Caption*** | ***Description of Function*** |
|---|---|
| Quote Number | The unique identifier to this quote that will be used for all future reference to this analysis. |
| Ship To Location | Allows the user to select which PKI site is the receiving site. This information drives duty rate, freight service, site visit expenses, accessorial charges, and static financial rates. |
| Part Number | The user will choose from the selection(s) made in Step 1. |
| Part Type | As mentioned in Chapter 5, the user selects either HLA, CC, OEM, or STD |

| ***Field Caption*** | ***Description of Function*** |
|---|---|
| Instrument | If the buyer knows specifically which instrument (finished good) the part will be used for, it can be captured for future product costing analysis. |
| HTS Code | The available choices from the drop down box will be the categories resulting from a filtering process on commodity description, commodity code, or part description as described in Step 2. |
| Evaluation Horizon | The model is capable of evaluating the sourcing decision for any period of time between one (1) and five (5) years. It was estimated that no contract would be executed for less than one (1) year or greater than five (5) years. The financial calculations in the model use this information to determine the NPV of each sourcing alternative. |
| Hazardous Material and Climate Control | If checked, additional freight cost is considered due to the nature of the material being shipped. |
| Comments | Allows the user to enter meaningful comments that will remain with the quote in the archive. |

Table 6: Common Data Field Descriptions

**Step 4:**

The data elements required in step 4 require much more analysis by the user and are the primary drivers of the flexibility and robustness of the model. The scenario alternatives suggested in Figure 8 are enabled through this step of the model. The GUI shown below in Figure 20 is organized by functional area which will be described further in subsequent paragraphs. The application of each data element will be described later in this chapter.


Figure 20: Unique Data Entry Screen

**Section A: Data Recovery**

Each quote is stored in an archive in the data warehouse for future reference or retrieval. Should a future sourcing analysis include the same or a subset of the same suppliers, an old quote can be recycled. If an existing quote is selected from the drop-down boxes, all fields in the screen will be populated with archived data and specific fields for the new proposal can be populated.

**Section B: Baseline Data**

This section is used to identify one to three suppliers that will be considered in the sourcing analysis. Additionally, a unique identifier (such as A, B, or C) is used to associate each supplier as a part of the overall quote analysis. Consequently, each supplier will have a *primary quote – sub-quote number* reference in the future. In Figure 20, MIT would have an identifier of "ALLMODES-A" that ties data specific to vendor MIT within a specific quote. The final component to enter is the cost of the part. It is worth mentioning that the model supports three currencies, USD, Euro, and the Singapore Dollar. Negotiations in any other currency must be converted to the local sourcing site currency.

**Section C: Origin Data**

The user must determine the country of origin and region of origin for both the manufacturing of the product and where the finished good will ship from. Freight costs will be calculated on the finished goods ship-from location. This information is useful in the scenario planning to understand the potential freight cost impact of a forward stocking location or fulfillment center that may be located in close proximity to a PKI manufacturing site.

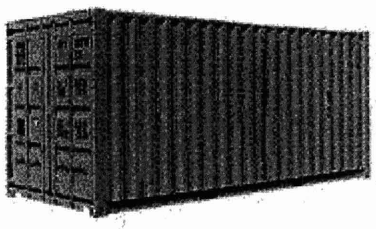
**Section D: Transit Data**

This section requests key transportation data for each supplier. Up to three different transportation modes (e.g. air, ground, or ocean) and associated lead times may be selected. It is possible that the user select the same mode with different lead times to simulate different classes of freight service. Also, the freight terms and other specialty cases of freight payment and custom clearances can be added to the freight cost. Finally, if ocean freight is requested, the user can provide an approximate percentage of a standard ocean container (see Figure 21) that will be used in the shipment of goods.[12]

[12] There is an assumption that any partial ocean container could be consolidated with other shipments through a freight forwarder and only the used portion of the container cost applied to PKI.

## Ocean Container Dimensions

**STANDARD 20'**



| | | |
|---|---|---|
| INSIDE LENGTH | 19'4" | 5.89 m |
| INSIDE WIDTH | 7'8" | 2.33 m |
| INSIDE HEIGHT | 7'10" | 2.38 m |
| DOOR WIDTH | 7'8" | 2.33 m |
| DOOR HEIGHT | 7'6" | 2.28 m |
| CAPACITY | 1,172 ft³ | 33.18 m³ |
| TARE WEIGHT | 4,916 lb | 2,229 kg |
| MAX. CARGO | 47,999 lb | 21,727 kg |

Figure 21: Standard Ocean Container[13]

**Section E: Packaging Data**

To allow the model flexibility in how it calculates the landed cost, the model supports multiple packaging configurations. The model uses the terminology "carton," which refers to any size or design package used to transport materials. During several examples with the model, a carton was defined as a cart, a pallet, a box, and an ocean container. By loosely defining a carton, the model is not constrained to any type of part or any conventional shipping method. The user is then asked to input the dimensions of the carton, which will be used to calculate the dimensional weight of the shipment. Depending on the shipment mode, the greater of dimensional weight or actual weight is used to ensure an accurate freight rate estimate. Another required input is the number of units that will fit in the carton as it has been defined. As a note, the inputs for "C1", "C2" and "C3" correspond to each shipping mode available for one supplier. Finally, if specific or unique packaging costs exist to ship material from a supplier to a manufacturing site, these costs can be captured as unique costs to each scenario. To achieve the most accurate landed cost comparison, it is advantageous for suppliers, who would normally roll all costs into material cost, to separate out individual cost line items so the model can treat each cost element comparison on a similar basis.

**Section F: Ordering Data**

This section of the data input process is dedicated to understanding order frequency and the freight service alternatives that exist for a supplier. Much like carton configurations, order

[13] Foreign Trade Online. Foreign Trade Company Information. 20 February 2008. <http://www.foreign-trade.com/reference/ocean.cfm>

frequency can also be dependent on transportation mode and the resulting lead times. Therefore, for each scenario being executed, the user may enter the order frequency with which an order will be placed (using weeks as the unit of measure). Since many firms use blanket purchase orders, automated Kanban type systems, economic order quantity (EOQ) models, etc. the user may consult any other systems or information sources to ensure the correct order period is entered. This data will be used to determine the number of shipments required to fulfill the annual demand requirements.

Next, there are many different types of freight service available, depending on the location of the manufacturing site. Table 7 shows the various alternatives by region.

| United States Available Freight Classes | UK Available Freight Classes | Singapore Available Freight Classes |
|---|---|---|
| Ground | Ground | Ground |
| Ocean Container | Ocean Container | Ocean Container |
| International Freight - Economy | UK - Express | Singapore - Air |
| International Freight - Priority | UK - Express Saver | |
| International Package - Economy | | |
| International Package - Priority | | |
| US - Domestic Air | | |

Table 7: Available Freight Class by Region

By allowing the user to choose with freight class to use in the model, trade-offs can be analyzed between any service and the associated lead times.

**Section G: Finance Data**

A unique cost component that is considered in the model is the impact on cash flow by reviewing payment terms and discounts. The calculations will be described in Section 7.5. A discount may be offered from a supplier on the cost of the material if the payment is made within a certain number of days of receiving the invoice and much sooner than the contractual payment terms. For example, 2/10 Net 30 requires the invoice to be paid within 30 days, but the manufacturer would receive a 2% discount on material cost if the invoice is paid within 10 days. The model will consider the impact to cash based on this type of scenario.

**Section H: Other Data**

As was mentioned in the overall description of the model, there may be circumstances that arise in an operation that require special cost considerations. In this section, operational issues such as vendor managed inventory, special warehousing costs, tooling, and one-time charges can be included. Also, quite often new suppliers to an organization must be qualified and certified on the specific components they will be providing. If this is the case, the Engineering Qualification section is designed to drive expense calculation associated with site visits, quality audits, or other supplier visits that may be required.

As a note, to maintain flexibility in the model, the data required to run an analysis can range from very simple to extremely complex. Therefore, only 19 fields of a possible 173 are required to run the simplest of models, but the model has the capacity to handle a variety of inputs that will shape the landed cost for any one part/supplier relationship.

**Step 5:**

Now that all of the necessary data has been entered for the model, the next step is to archive the data that was input in steps one through four. By archiving the data, the information entered on a supplier, used to source multiple products, can be reused multiple times to reduce the data entry time requirement. Archiving/storing the data is a mandatory step so the necessary table structures are updated with data required to run the model.

**Step 6:**

The final mandatory step in the model is to execute the landed cost calculations. As was discussed earlier, the landed cost calculations are done in a dynamic model that pulls data from the database each time the model is run. The user ultimately selects which supplier comparisons they would like to have included in the model. Because the model archives data using the quote number and sub-quote number as key reference fields, any supplier scenario that exists in the database can be pulled into the landed cost model. Figure 22 diagrams two analysis opportunities. A customary method for using the model would be to consider three different suppliers, included in Primary Quote A, with Sub-Quotes 1, 2, and 3, all bidding for the same part. These selections could be made and the results would be calculated. However, if the supplier is bidding on multiple parts against multiple competitors, the model can be used to understand the cost of creating a package of parts. In the example, suppose Supplier X is represented by C-3, D-2, and E-1 (each of which is a unique quote for a unique part). The model has the capability to calculate the landed cost for each of these three parts, for one supplier, thereby creating an aggregated landed cost.

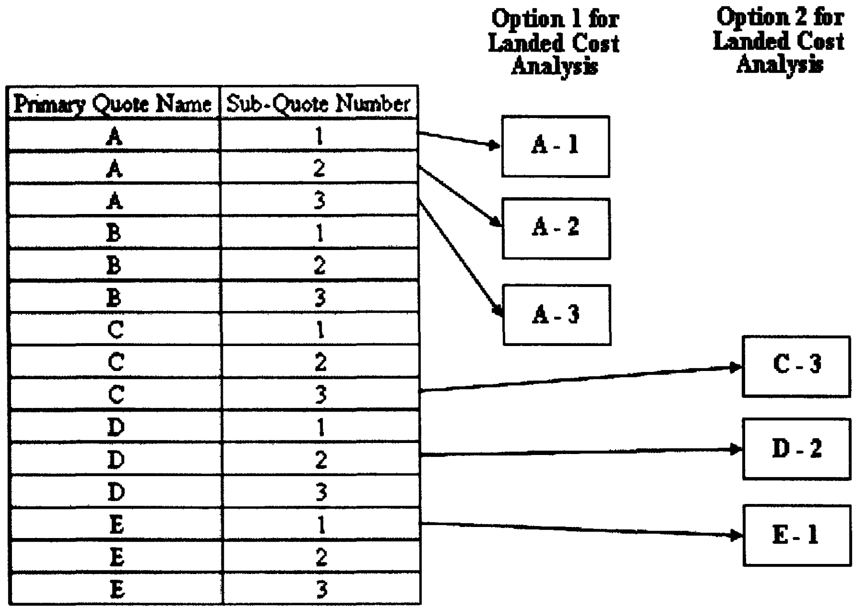



Figure 22: Landed Cost Scenario Selection

To calculate the landed cost, the model was developed in modules, each representing a major cost category. As a definition, the major cost categories are Freight and Trade Compliance, Inventory Management, Purchasing Expense, and Financial Analysis. Each of the costs identified in Chapter 3 are included in one of these categories. The following sections will describe the calculations that take place to determine the total landed cost.

## 7.2 Freight and Trade Compliance Cost Calculation

To portray how the freight and trade compliance cost is calculated, Figure 23 will be used as a reference for the various components that are included. This figure represents one "cell" of the 3x3 matrix of freight calculations which represent all possible scenarios in the model.

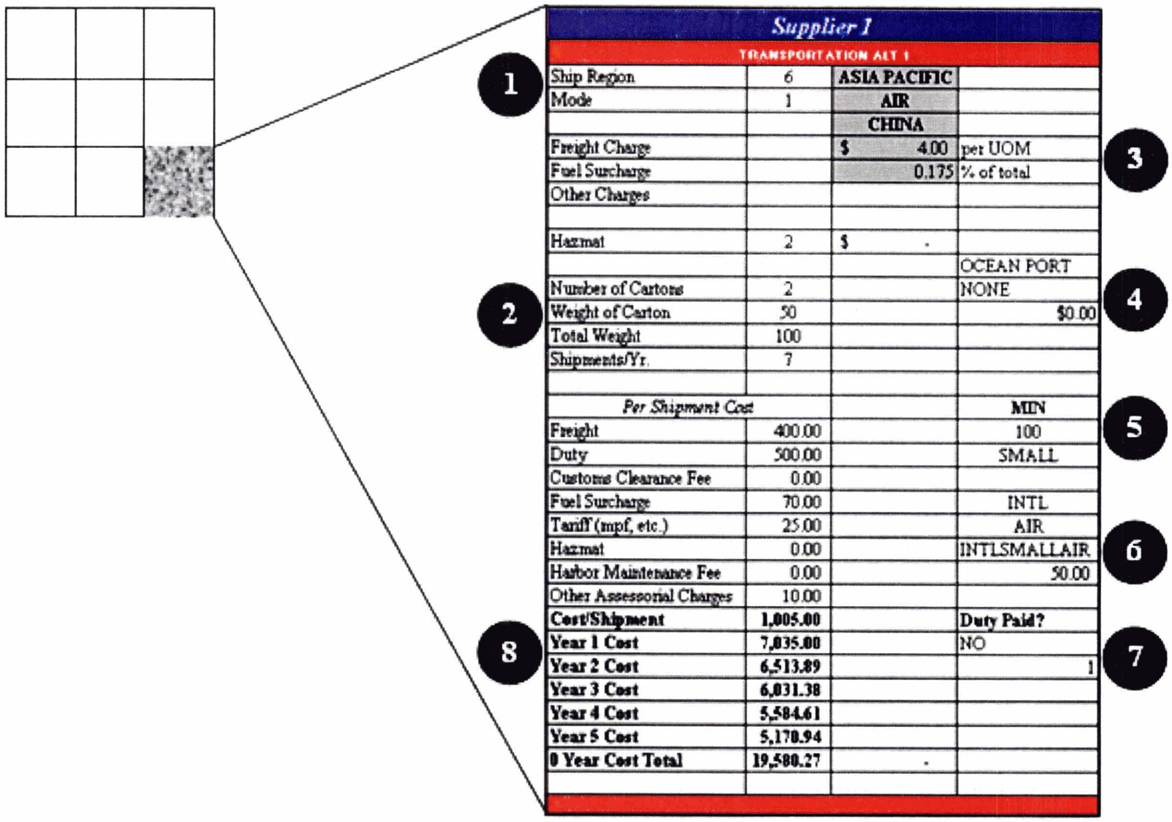



Figure 23: Freight Cost Calculations

### 7.2.1 Material Origin – Component 1

From the initial data set provided by the user, the model utilizes two key factors to begin determining freight cost; the location where the material or assembly will originate and the mode of transport. The model contains both the "region" of origin (identified as Asia Pacific above), as defined by the organization and a specific country.

### 7.2.2 Carton Configuration and Shipment Frequency – Components 2 and 5

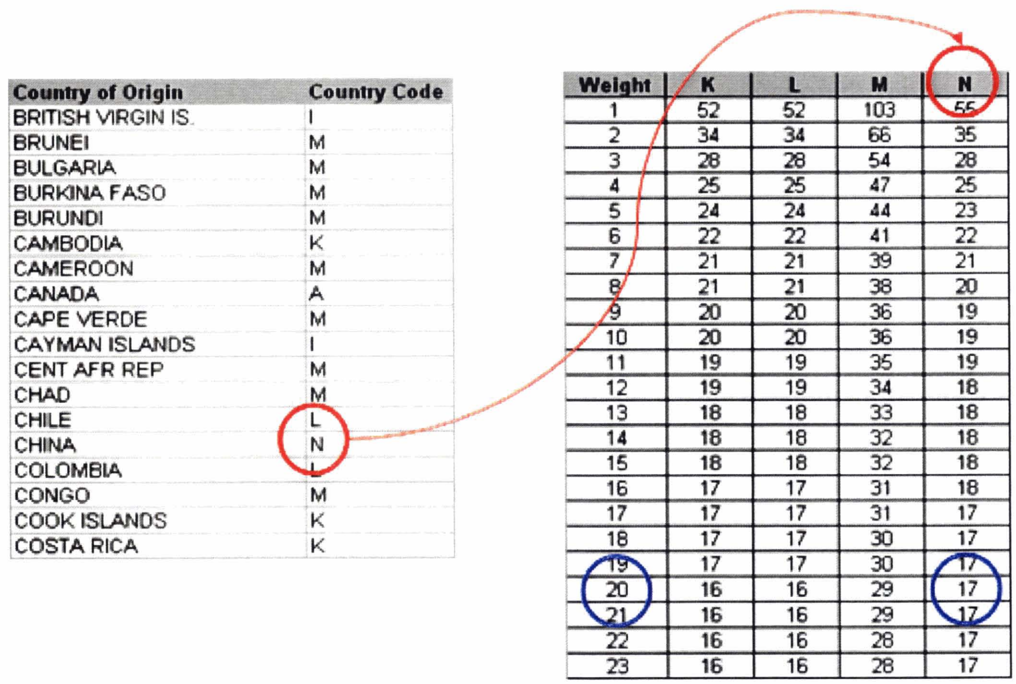
In order to calculate the cost of a shipment, the model must have the number of cartons required per shipment, the weight of each carton, the total shipment weight, and the number of shipments required per year. To determine this information, the following formulas are used:

- Number of cartons required per shipment = total annual demand ÷ shipments per year ÷ number of units per carton (as input by the user);

- Weight of carton = MAX(actual unit weight * number of units per carton, dimensional weight of the carton)[14];
- Total shipment weight = Number of cartons required per shipment * carton weight
- Shipments per year = 52 weeks per year ÷ order frequency (in weeks).

### 7.2.3 Freight Rate – Component 3

Now that the origin and shipping configuration have been determined, the freight rate can be calculated. The rate is determined by several factors: origin country, mode, and shipment weight. Through verification with primary shipping partners, total shipment weight serves as the basis for the overall rate, not the number of individual cartons being shipped. Using the freight service options from Table 7, the model uses an intercept analysis process to determine the appropriate freight rate per pound (US) or kilogram (UK and Singapore). Within a freight rate table, a country is assigned a "zone", which when coupled with the total shipment weight, can be used to determine the rate. An example of this lookup process is diagramed in Figure 24.



| Country of Origin | Country Code |
|---|---|
| BRITISH VIRGIN IS. | I |
| BRUNEI | M |
| BULGARIA | M |
| BURKINA FASO | M |
| BURUNDI | M |
| CAMBODIA | K |
| CAMEROON | M |
| CANADA | A |
| CAPE VERDE | M |
| CAYMAN ISLANDS | I |
| CENT AFR REP | M |
| CHAD | M |
| CHILE | L |
| CHINA | N |
| COLOMBIA | L |
| CONGO | M |
| COOK ISLANDS | K |
| COSTA RICA | K |

| Weight | K | L | M | N |
|---|---|---|---|---|
| 1 | 52 | 52 | 103 | 55 |
| 2 | 34 | 34 | 66 | 35 |
| 3 | 28 | 28 | 54 | 28 |
| 4 | 25 | 25 | 47 | 25 |
| 5 | 24 | 24 | 44 | 23 |
| 6 | 22 | 22 | 41 | 22 |
| 7 | 21 | 21 | 39 | 21 |
| 8 | 21 | 21 | 38 | 20 |
| 9 | 20 | 20 | 36 | 19 |
| 10 | 20 | 20 | 36 | 19 |
| 11 | 19 | 19 | 35 | 19 |
| 12 | 19 | 19 | 34 | 18 |
| 13 | 18 | 18 | 33 | 18 |
| 14 | 18 | 18 | 32 | 18 |
| 15 | 18 | 18 | 32 | 18 |
| 16 | 17 | 17 | 31 | 18 |
| 17 | 17 | 17 | 31 | 17 |
| 18 | 17 | 17 | 30 | 17 |
| 19 | 17 | 17 | 30 | 17 |
| 20 | 16 | 16 | 29 | 17 |
| 21 | 16 | 16 | 29 | 17 |
| 22 | 16 | 16 | 28 | 17 |
| 23 | 16 | 16 | 28 | 17 |

**Example: A 20 lbs. shipment from China would cost $17/lbs.**

Figure 24: Freight Rate Lookup

[14] Dimensional weight is based on carton volume and is used as an alternative to actual shipment weight. Dimensional weight for US domestic shipments = (L (in) * W (in) * H (in))/194. Dimensional weight for international shipments = (L (in) * W (in) * H (in))/166. Calculations vary in centimeters for shipments to the UK and Singapore. UPS Online. United Parcel Service Company Information. 20 August 2007. <http://www.ups.com/content/us/en/resources/prepare/dim_weight.html>

Further, by using the mode of transportation, the correct fuel surcharge will be incorporated in the model. The computation process described above is used for air and ground freight service. Currently, PKI uses very little ocean freight, so negotiated rates were not available for the model. However, as a close approximation to likely rates, estimates were taken from Maersk, one of the leading ocean freight carriers in the world.[15] If ocean freight is requested, the model uses the standard ocean container[16] charge from the closest port to the supplier ship-from location to the closest port for a PKI manufacturing site.

### 7.2.4 Delivery from Ocean Port – Component 4

If ocean freight is utilized, the port of delivery is selected based on the origin of the material. The model will calculate the ground freight cost to move the material in the ocean container to the manufacturing site, based on the port of arrival. This additional freight cost is added to the per shipment cost of the ocean movement.

### 7.2.5 Shipment Weight Determination – Component 5

As described in the carton configuration section above, the model will determine the maximum of the actual shipment weight and the dimensional weight. This capability is utilized to ensure the freight cost calculation is as accurate as possible. To calculate the actual shipment weight, the model uses weights and measures located within the ERP system or provided by the user and the carton capacity. An additional purpose is to consider the packaging material required to safely ship material from a supplier site. If significant packaging is required, the dimensional weight may exceed the actual weight. If this is the case, the user of the model will have the ability to see the shipment weight and use the information to drive package reengineering or change a shipping container to influence the overall weight of the raw material.

### 7.2.6 Minimum Freight Cost – Component 6

Another cost component which must be considered is a minimum freight charge for any air or ground shipment. Most carriers will apply a minimum shipment cost, using a weight break system, regardless of the actual cost calculated from negotiated rates. The result shown in Figure 23 uses the freight mode, shipment weight, and shipment origin to determine a minimum freight

[15] Maersk Online. Maersk Company Information. 1 October 2007. <http://www.maersk.com/en>
[16] See Figure 21: Standard Ocean Container for specifications on a standard ocean container

cost. If this cost is greater than the actual shipment cost, the minimum is used in the landed cost determination.

### 7.2.7 Duty Recognition – Component 7

Depending on the manufacturing location and the location of the supplier, duty rates may or may not apply. Additionally, the duty payment may be negotiated with the supplier to be paid by the supplier, regardless of the freight terms. Another example would be if a supplier is located within the EU and the manufacturing site is in the UK, there would be no duty applied. In any case, the user would be able to indicate if duty should or should not be included in the model. Again, this is a feature of the model that creates flexibility to deal with a variety of international trade scenarios.

### 7.2.8 Freight and Trade Compliance Cost Calculation – Component 8

The final freight and trade compliance cost is calculated based on each of the components listed; freight, duty, customs clearance fees, fuel surcharge, tariffs, hazardous material charges, harbor maintenance fees (for ocean freight), and other assessorial charges that may apply to the shipment. This cost is the per shipment cost and must be multiplied by the number of required shipments, as described in Component 2 above. Subsequently, since the model is capable of considering up to a five (5) year horizon for the analysis, the net present value (NPV) of this annual cost over the next five (5) years is calculated, using a company standard cost of capital. Based on the number of years selected for the evaluation horizon, the appropriate total cost (using NPV) is determined.

In summary, the Freight and Trade Compliance cost calculations contain a multitude of variables. The scenario-based construction of the model is designed to allow the consideration of supplier trade-offs, which may or may not result in the lowest freight and trade compliance cost. Finally, to ensure accuracy in the freight cost calculator, several scenarios, based on actual shipments, were tested in the model. Freight rate estimates were validated against shipping invoices for completeness and total cost accuracy.

## 7.3 Inventory Management Cost Calculation

To determine the inventory carrying cost associated with a supplier selection, three specific types of inventory are considered; safety stock, cycle stock, and in-transit inventory. The following sections will provide insight into how the calculations are performed and what data is required to understand how the cost and quantity of inventory is considered when making a strategic sourcing decision.

### 7.3.1 Safety Stock

To determine safety stock, three variables are required; service level (to define *z,* the multiplier in the safety stock calculation*),* demand and lead time variability ($\sigma$), and lead time. Each of the variables was determined in the following manner.

- Service/performance level – during the data entry process, the user may select a service level between 90% and 99.9%. The corresponding z-value is utilized for safety stock determination.
- Demand variability – using approximately 16 months of demand forecast, upon entry of the part number being sourced, the model determines the monthly demand variability from the monthly forecasts. The model assumes forecasts are unbiased so that the standard deviation of the demand is equal to the standard deviation of the forecast error.
- Lead time – the user of the model can enter the appropriate lead time for up to three modes of transportation, for each of three suppliers. The entry, in days, is converted to months to correlate with demand variability.
- Lead time variability – in this model, the safety stock must account for both demand and lead time variability. To determine lead time (which is a random variable) variability, delivery performance of the top 80 suppliers was analyzed over a six month period to estimate the on-time delivery capability of each supplier. One shortcoming of the data was that no specific number of days late was captured in the data, so an estimate of three (3) days was used for any late delivery.[17] For computation purposes, if a supplier being considered is one of the top 80, the actual delivery performance is used in the safety stock calculation. However, if a supplier is not in the top 80, the average of the top 80 serves as a proxy for these suppliers.

[17] Based on interviews with purchasing management, buyers, inventory management, and warehouse team members, the value of three (3) days for a "late" shipment was agreed upon.

Finally, since lead time is considered a random variable, the generic computation for the standard deviation with respect to lead time, $\sigma_T$, is as follows:

The standard deviation of a random variable $X$ is defined as:

$$\sigma = \sqrt{\mathrm{E}((X - \mathrm{E}(X))^2)} = \sqrt{\mathrm{E}(X^2) - (\mathrm{E}(X))^2}$$

where E($X$) is the expected value of $X$.[18]

The following calculations are done to compute σ that includes demand and lead time variability.

$$\sigma = \sqrt{(\mathrm{T} * \sigma_{\mathrm{D}}^2) + (\mathrm{D}^2 * \mathrm{Var(T)})}$$

$$\mathrm{T} = \mathrm{E(T)} = (\%\ \text{on time} * \mathrm{LT}) + (\%\ \text{late} * (\mathrm{LT} + \text{days late}))$$

$$\mathrm{Var(T)} = \sigma_{\mathrm{T}}^2 = \mathrm{E(T^2)} - [\mathrm{E(T)}]^2$$

$$\sigma_{\mathrm{T}} = \sqrt{\mathrm{Var(T)}}$$

$$\therefore \sigma = \sqrt{(\mathrm{LT} * \sigma_{\mathrm{D}}^2) + (\mathrm{D} * \sigma_{\mathrm{T}}^2)}$$

Where T, LT = lead time, D=demand.

Once the combined demand and lead time variability is calculated, the appropriate safety stock can be determined using the formula, $z * \sigma * \sqrt{L}$.

### 7.3.2 Cycle Stock

The average inventory is computed by using the reorder quantity calculated from the annual demand, order frequency, and safety stock and assumes a continuous review policy. The model uses as a continuous review policy since inventory levels are reviewed each day (in many cases it is done automatically by a kanban type system used by PKI). It also assumes random daily demand follows a normal distribution, inventory holding cost is per item per unit time, and a specific service level is required of the supplier (Simchi-Levi, Kaminski, and Simchi-Levi 2nd ed. 58-60). Therefore, the average inventory held in the system uses the following formula: $\frac{Q}{2} + z * \sigma * \sqrt{L}$, were Q represents the reorder quantity.

[18] Wikipedia Online. 2007. Wikipedia Online Encyclopedia. 19 November 2007. <http://en.wikipedia.org/wiki/Standard_deviation#Standard_deviation_of_a_random_variable>

### 7.3.3 In-Transit Inventory

To determine the carrying cost associated with in-transit inventory, the freight terms must be known. Based on the freight terms, the model computes during what duration of the lead time the inventory is owned by PKI. In many cases, the value of this inventory may be accrued in an account and then transferred to a line of business upon receipt. Also, the payment terms will determine the impact on cash flow and working capital. However, for the model, it was important to consider the financial impact of owning the inventory during this transit period. The ownership would be more critical depending on the mode of transportation and the projected lead times. Therefore, Table 8 describes the assumptions that were used for inventory ownership based on the lead time.

| Index | Freight Terms (Incoterms): | Where Ownership for PKI occurs | Portion of PKI ownership |
|---|---|---|---|
| 1 | CFR = Cost and Freight | at US port | 33% |
| 2 | CIF = Cost, Insurance, and Freight | at US port | 33% |
| 3 | CIP = Carriage and Insurance Paid To | at US port | 33% |
| 4 | CPT = Carriage Paid To | at US port | 33% |
| 5 | DAF = Delivered at Frontier | at US port | 33% |
| 6 | DDP = Delivered Duty Paid | at final destination | 0% |
| 7 | DDU = Delivered Duty Unpaid | at US customs clearance | 25% |
| 8 | DEQ = Delivered Ex Quay | at US customs clearance | 25% |
| 9 | DES = Delivered Ex Ship | at US port | 33% |
| 10 | EXW = ExWorks | at supplier mfg site | 100% |
| 11 | FAS = Free Alongside Ship | at point of transit (air/ocean) | 95% |
| 12 | FCA = Free Carrier | at point of transit (air/ocean) | 95% |
| 13 | FOB Origin = Free On Board | at point of transit (air/ocean) | 95% |
| 14 | FOB Destination = Free On Board | at point of transit (air/ocean) | 20% |

Table 8: In-transit Inventory Adjustment Factors

Using the table above, the final column indicates during what percentage of the overall lead time PKI owns the inventory.[19] These percentages are used to calculate the inventory carrying cost = annual demand * LT * LT reduction factor * cost of the component * cost of capital rate.

In conclusion, the carrying costs associated with safety stock, cycle stock, and in-transit inventory are aggregated for the first year of the supplier relationship. Inventory costs in subsequent years of the contract are determined by taking the NPV of the annual cost. As in the freight cost calculation, the number of years of cost is determined by the evaluation horizon

[19] The percentages of ownership are based on estimates from anecdotal evidence. However, since the model is dynamic in nature, the rate can be adjusted based on actual shipment tracking data in the future.

provided by the model user. Table 9 shows an example of the annual inventory carrying cost and then the NPV of the cost based on a three (3) year evaluation horizon.

| | |
|---|---|
| Total 1 Year Inventory Carry Cost | $ 1,400.00 |
| Year 2 - NPV of Inventory Carry Cost | $ 1,300.00 |
| Year 3 - NPV of Inventory Carry Cost | $ 1,200.00 |
| Year 4 - NPV of Inventory Carry Cost | $ 1,050.00 |
| Year 5 - NPV of Inventory Carry Cost | $ 900.00 |
| Total 3 Year Inventory Carrying Cost | $ 3,900.00 |
| | |
| Evaluation Horizon - from user input | 3 |

Table 9: Inventory Carrying Cost Example

## 7.4 Purchasing Cost Calculation

The purchasing related costs included in the landed cost model are the material cost of the parts, packaging costs, warehouse fees, supplier qualifications, and any one-time charges that are not explicitly included in the other cost components. The calculations or definitions for each component are included below:

- Material cost = annual demand * cost/unit
- Packaging cost = cartons/shipment * shipments/year * orders/year * cost/carton
- Warehouse fees are provided by the user after consultation with warehouse management team. These costs may include cost/square foot, additional labor cost for material handling, etc. No specific guidelines were provided on this cost given the variety of alternatives that may drive warehouse cost. A primary example of warehouse cost would be if PKI considered an ocean container of material, any temporary warehouse space or additional handling required for a large volume could be included in this cost category.
- One-time charges are any significant costs that are relevant to the sourcing decision and are not included in another cost factor.
- Supplier qualification = engineers required * visits required/evaluation period * length of stay/visit. Based on the origin of the engineering team (US, UK, or Singapore), the model includes estimates of airfare, hotel, and per diems associated with the region of the world where the supplier is located (as entered by the user). Depending on the complexity of the part and history with the supplier, this cost was included given its potential relevance to the

overall cost of selecting a specific supplier. As with other costs in the model, if no supplier qualification is required, the data entry can be omitted with no further impact to the model calculations.

In conclusion, the purchasing costs are straight-forward calculations, but may comprise a large part of the total landed cost. Often, the material cost is the driving factor in the sourcing decision, but as the landed cost model demonstrates, is only one of many cost factors that must be analyzed prior to entering into a supplier relationship.

## 7.5 Financial Analysis Cost Calculation

The final costs included in the model are those associated with the finances of the sourcing decision, specifically, tooling and fixtures, payment terms, and any discounts being offered by the supplier. Each section below explains requirements and analysis for each factor.

### 7.5.1 Tooling and Fixtures

Many of the parts that PKI procures require tooling or fixtures in the manufacturing process. There are two primary scenarios that exist to ensure the supplier has the correct tooling. First, a supplier may own the tooling themselves. Second, PKI may buy the tooling and provide it for the suppliers use. If the second option prevails, the cost of the tooling is attributed to the cost of doing business with a supplier. However, the specific cost that is included is the annual depreciation of the tooling for the number of years of the supplier contract. A straight line depreciation schedule over five (5) years is used in the calculation. Like other cost factors, the NPV of the costs beyond year one (1) will be used for the landed cost analysis. Additional assumptions used for this analysis were no specific salvage value for the tool/fixture at the end of its useful life and if the tool is being moved from supplier A to supplier B, the remaining depreciation would be applied to the new supplier analysis. If PKI owns the tool/fixture and must move it to a new supplier, the cost of that move is an example where the one-time cost field may be used.

### 7.5.2 Payment Terms

Many times, suppliers offer different payment terms such as Net 30, Net 60, or Net 90. However, most supply chain cost models ignore the potential impact on working capital of the difference in the payment terms. Figure 25 provides a high-level example of how the payment term comparison process is executed in the model.

| | | | |
|---|---|---|---|
| Annual Borrowing Rate | 7.3% | | |
| Daily Borrowing Rate | 0.02% | | |
| | ***Supplier A*** | ***Supplier B*** | ***Supplier C*** |
| Payment Terms | Net 30 | Net 45 | Net 60 |
| Invoice Due (days) | 30 | 45 | 60 |
| "Best Case" Terms for PKI | 60 | 60 | 60 |
| Difference (Best – Actual) | 30 | 15 | 0 |
| Annual Invoice | $1,000,000 | $800,000 | $900,000 |
| Impact on Working Capital (using Difference) | $6,000 | $2,400 | $0 |
| Impact Over Three (3) Year Contract | $18,000 | $7,200 | $0 |

Figure 25: Payment Term Impact

The concept behind the analysis is to understand the "cost" of working with a supplier who is requiring faster payment than another supplier. In the example above, the optimal payment term alternative is 60 days (from Supplier C). Understanding that a longer payment term may be negotiated, if Net 60 is the result of the negotiation, this would be considered the best alternative. However, if Suppliers A and B are not willing to offer the same terms, there is an impact on cash for PKI if either are selected. In the case above, Supplier A's terms are 30 days worse than the optimal. Therefore, the opportunity cost of capital for PKI is the value of the annual invoices over the 30 day difference. To determine the impact on cash, the following formula is used: annual invoice * daily borrowing rate * difference in days to the best alternative. As shown above, $1,000,000 * 0.02% * 30 days = $6,000 per year. For the landed cost model, this impact on cash is treated as a "cost" of doing business with that supplier and is added in the landed cost. A similar analysis can be done of Supplier B, where the difference from actual to optimal payment terms in only 15 days.

### 7.5.3 Discounts

A final cost component to consider is the potential impact of discounts that a supplier may offer for early invoice payment. Using an example provided earlier, payment terms of 2/10 Net 30 requires the invoice to be paid within 30 days, but the manufacturer would receive a 2% discount on material cost if the invoice is paid within 10 days. There are many factors that drive the decision about accepting discounts, including cash position and supplier relationship, but for the model, the analysis conducted determines if the discount offered is better or worse than the opportunity cost of holding on to the payment for the full extent of the payment terms. Figure 26 continues the previous example by adding new discount data.

| | | | |
|---|---|---|---|
| Annual Borrowing Rate | 7.3% | | |
| Daily Borrowing Rate | 0.02% | | |
| | ***Supplier A*** | ***Supplier B*** | ***Supplier C*** |
| Payment Terms | Net 30 | Net 45 | Net 60 |
| Invoice Due (days) | 30 | 45 | 60 |
| "Best Case" Terms for PKI | 60 | 60 | 60 |
| Difference (Best – Actual) | 30 | 15 | 0 |
| **Discount Offered (% discount/days to pay)** | 1/5 | .05/15 | 1/10 |
| Days Between Discount and Full Term | 30 – 5 = 25 | 45 – 15 = 30 | 60 – 10 = 50 |
| Annual Invoice | $1,000,000 | $800,000 | $900,000 |
| Value of Discount (discount % * invoice) | $10,000 | $4,000 | $9,000 |
| Opportunity Cost of Cash if Held for Duration | $5,000 | $4,800 | $9,000 |
| Difference (Discount – Opportunity Cost) | $5,000 | ($800) | $0 |

Figure 26: Value of Payment Discounts

Using Supplier A as an example, if the supplier offered PKI a discount of 1% if the invoice is paid within 5 days of receipt (1/5), PKI would like to know which is better for their cash position, either taking the discount or holding on to the payment for the full duration of the payment terms (30 days in this case). As is shown above, the value of the discount is 1% of $1M, or $10,000. If PKI were to hold on to the cash for the additional 25 days (Net 30 – 5 days), the opportunity, using the daily borrowing rate, is only $5,000. Therefore, the value of the discount is more significant than holding on to the cash. As a result, the total landed cost would be *reduced* by $10,000 annually. Similarly for Supplier B, the example shows that holding on to the cash for an additional 30 days (Net 45 – 15 days) is better by $800 than accepting the discount. Finally, for Supplier C, it is shown that the alternatives are neutral as both alternatives yield the same benefit to PKI.

In conclusion, the financial cost analysis allows for consideration of points which may be negotiated with the supplier. However, the model provides the functionality to compare these alternatives to understand what trade-offs in terms, discounts, etc. are most beneficial for the overall supplier-manufacturer relationship. Concessions may be made by both parties to reach an agreement and those terms can be modeled to fully understand their impact on the total landed cost.

## 7.6 Chapter Summary

Upon completion of all cost calculations, the model produces a sourcing summary for each supplier. Figure 27 shows an example output.

| | Supplier A | | Supplier B | | Supplier C | |
|---|---|---|---|---|---|---|
| Analysis for Part Number: ABC123 | ABC123 | | ABC123 | | ABC123 | |
| 3 Year Demand Total | 2,000 | | 2,000 | | 2,000 | |
| Evaluation Period (yrs.) | 3 | | 3 | | 3 | |
| HTS/Part Description | Electrical Cables | | Electrical Cables | | Electrical Cables | |
| Shipping Origin | ASIA PACIFIC | | LATIN AMERICA | | INDIA | |
| Quote number | Test-1 | | Test-2 | | Test-3 | |
| Summary Over 3 Year Horizon Scenario 1 | | | | | | |
| Freight Mode | AIR | | GROUND | | AIR | |
| Freight | $ | 500,000 | $ | 100,000 | $ | 700,000 |
| Inventory Carrying Cost | $ | 12,000 | $ | 9,000 | $ | 11,000 |
| Material Cost | $ | 200,000 | $ | 400,000 | $ | 300,000 |
| Packaging Cost | $ | 50,000 | $ | 40,000 | $ | 60,000 |
| Tooling Costs | $ | - | $ | 10,000 | $ | - |
| Finance Charges | $ | 2,500 | $ | - | $ | - |
| Material Cost Reductions from Discounts | $ | - | $ | - | $ | (4,500) |
| | | | | | | |
| Engineering Qualification | $ | - | $ | 15,000 | $ | - |
| Warehouse and One-Time Charges | $ | - | $ | - | $ | - |
| Assist Cost | $ | - | $ | 30,000 | $ | - |
| Assist Duty | $ | - | $ | 1,500 | $ | - |
| | | | | | | |
| Total Landed Cost | $ | 764,500 | $ | 605,500 | $ | 1,066,500 |
| % Savings over Highest Cost Supplier | | 28% | | 43% | | 0% |
| Total Savings over Highest Cost Supplier | $ | 302,000 | $ | 461,000 | $ | - |
| PPV Savings over Highest Cost Supplier | $ | 200,000 | $ | - | $ | 100,000 |
| Weighted Piece Part Price | $ | 382 | $ | 303 | $ | 533 |
| Risk Adjusted Cost | $ | 843,000 | $ | 750,000 | $ | 1,150,000 |

Figure 27: Landed Cost Model Summary

There are five key figures and statistics that are included near the bottom of the summary. First, the total landed cost from all cost components is calculated. Second, the output shows the percentage cost difference between the highest landed cost supplier and each individual supplier. Third, considering the total landed cost, the total potential savings of each supplier when compared to the highest cost supplier is displayed. Fourth, many manufacturers use PPV as one consideration when making sourcing decisions. The model displays the PPV savings of each supplier when compared to the highest cost supplier. The model uses the "material cost" line for this analysis. Finally, the risk-adjusted cost is provided. This result is using the methodology described in Figure 14. The combination of these statistics allows PKI to compare and contrast supplier costs and understand the total cost savings or increases beyond individual cost fluctuations.

The landed cost model contains the functionality and capability to provide a wealth of information for making a strategic sourcing decision. Using real-time data, user expertise, and supplier quote information, PKI now has the ability to carefully analyze cost factors and scenarios prior to entering contract negotiations. Although the model is forward looking and is an estimate of cost, a summary of the benefits of the model include:

- Providing a holistic view of sourcing costs and risks;
- Allowing a range of analyses to be completed;
- Performing "what-if" analyses for use in supplier negotiation;
- Considering a wide variety of cost factors;
- Calculating a risk-adjusted cost using the supplier risk indices;
- Standardizing the cost analysis process, within the business, around one tool;
- Presenting support for sourcing decisions in low-cost countries, domestically, or otherwise;
- Contributing to other business factors used in the decision making process (e.g. supplier consolidation, global demand consolidation, supplier partnerships, etc.);
- Archiving quote information for future use and reference;
- Organizing data entry and navigation to simplify model use;
- Including operational differences for global sites;
- Allowing for expansion and portability to other PKI businesses.

# Chapter 8: Risk Analysis Model Development

The primary objective in understanding a risk profile for each supplier is to create a relative risk scale by which many suppliers can be compared. This model provides a unique, quantitative methodology for assessing risk, which by its nature, is somewhat subjective. However, by creating a common framework and analysis process, a more intuitive outcome can be generated and subjectivity minimized. Additionally, by understanding where risk is concentrated, mitigation strategies can be developed to ensure minimal supply chain interruption.
This chapter will describe how the risk analysis model and results are developed, using the utility-weight algorithm described in Chapter 6. There are three primary functions required to assess supplier risk; gather supplier data, compute a risk index, and analyze results. Each of these functions is described in the sections below.

## 8.1 Supplier Data Gathering

Assessing supplier risk requires a significant amount of data, most of which must be provided by the potential supplier. However, the most critical step in the process is the analysis of the supplier information by the Purchasing and Strategic Sourcing teams. The process is one which should be done collaboratively to ensure the most accurate information is provided for the risk analysis. In order to accomplish an efficient data gathering mechanism, a supplier questionnaire that correlates to the risk profile was developed. To acquire information that is critical for a supplier risk assessment, a supplier evaluation questionnaire was created.[20] The supplier questionnaire is critical for a number of reasons.

1. Establishes a baseline of information on a new or existing suppliers;
2. Standardizes the data needed from each supplier to uniformly analyze each potential supplier;
3. Initiates dialogue between PKI and the supplier about critical information that will be considered during the sourcing selection process;
4. Provides a dataset for the Strategic Sourcing team to utilize when visiting or reassessing suppliers for future contracts.

[20] Multiple suppliers were involved in fine tuning a questionnaire that PKI will use to gather pertinent risk information. The suppliers were involved to assess the feasibility of the questionnaire as well as the ease of use given the global nature of the current and future supply base.

The questionnaire asks the supplier to provide simple, direct answers to questions, which are converted to a numeric value and then utilized directly in the risk model. Examples of the types of questions that are included on the questionnaire are; yes/no responses to whether a supplier possesses one or many of 12 different technologies, yes/no responses to the supplier continuous improvement programs, an indication of specific R&D capabilities and skill sets, and financial performance records to assess financial strength and experience of a supplier. The questionnaire asks suppliers for key information that will be used in the utility-weight process and is designed to be sent out in advance of any sourcing analysis, so supplier capability and risk is known prior to any time sensitive sourcing analysis requirements.[21] Further, the purchasing and supplier development teams may also need the involvement of quality engineers, finance, logistics, and other support organizations to help interpret the results of the survey. To validate the questionnaire questions and data inputs, suppliers from around the world participated in a pilot to provide their feedback on the process. The intent of the pilot was to ensure suppliers in any country would find each question relevant and simple to understand. The questionnaire can be found in Appendix 2. Additionally, by collaborating with the Purchasing and Sourcing teams, an existing supplier survey was consolidated into the model and questionnaire, streamlining the documentation and data retrieval processes. The new questionnaire is an electronic form to help expedite completion and submission times for suppliers.

## 8.2 Risk Index Computation

To compute the risk index, as described in Chapter 6, each individual risk factor in the profile must be assessed using supplier input and PKI expertise. Chapter 6 also described how the weight of each risk was determined. The format of each scale contains the utility on the top of figure (always between 0 and 100, where a higher utility is indicative of higher risk) and the risk evaluation scale on the bottom of the figure. The evaluation scale was determined by subject matter experts (SME) in the respective risk area. These scales may differ within other organizations, but the dynamic model allows for them to be changed over time. To limit the subjectivity within the analysis, each supplier is evaluated on the same scale, regardless of geographic location, history with PKI, or otherwise. Another measure taken to ensure consistency was to validate each scale with SME in the US, UK, and Singapore. Consequently,

[21] A sample of the supplier qualification questionnaire can be found in Appendix 2.

when global suppliers are being evaluated, the tool may be used consistently and scales are not modified to influence a particular result in any one region of the world. To illustrate the calculations used for each of the risks, Figure 28 provides an example risk index assessment.

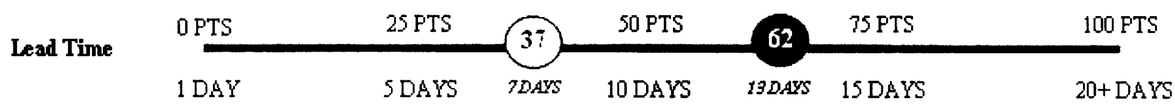



Figure 28: Utility Interpolation Example

Example: For the risk factor lead time, a sample scale developed assigns a utility value of 0 for a supplier who can provide material in 1 day or less and a utility value of 100 for any lead time greater than 20 days. Using input from a quote, supplier questionnaire, or team experience, any value between 1 and 20 would result in the interpolation[22] of the utility between the closest two points. For a supplier (A) with a response of 7 days, a utility score of 37 would result. A supplier (B) with a quoted lead time of 13 days would have a utility score of 62 (interpolating between 50 and 75 by using 10 days, 13 days, and 15 days as reference points). Ultimately, if the weight of the lead time risk factor was 6%, the individual risk index for this factor for Supplier A would be 6% * 37 = 2.22 and 6% * 62 = 3.72 for Supplier B. By aggregating the individual risk indices for each factor, an overall supplier risk index is computed, where the lower the risk index, the lower the supply chain risk for that supplier.

In the sections below, organized by risk category, the utility computation for each risk will be described, ultimately resulting in the ability to calculate a risk index for any supplier.

### 8.2.1 Purchasing and Organizational Risk

#### Geopolitical Risk

The geopolitical risk of a supplier is directly related to the risk of the doing business in the country where the supplier is located. Therefore, to assess geopolitical risk, a third part source that assesses global corruption is utilized for the model.[23] Transparency International ranks over 160 countries on a Corruption Perception Index (CPI). The CPI score is between one (1) and ten (10). Therefore, to assess geopolitical risk, the scale in Figure 29 is used.

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[22] Interpolation is defined as the construction of new data points between two known data points.
[23] Transparency International Online. 2007. Transparency International Company Information. 2 January 2008. <http://www.transparency.org/policy_research/surveys_indices/cpi/2006>

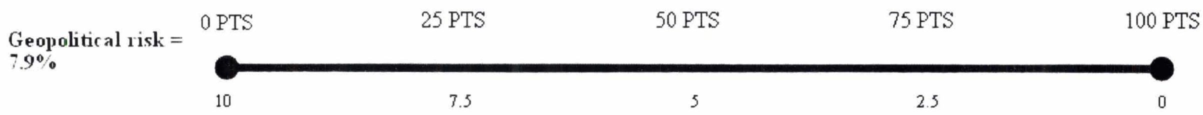



Figure 29: Geopolitical Risk Evaluation

Using a reverse linear scale, plotting the CPI score for the country where the supplier will manufacture the parts will provide the appropriate utility value.

**Capacity Utilization**

Capacity is measured on a complex non-linear scale as shown in Figure 30.

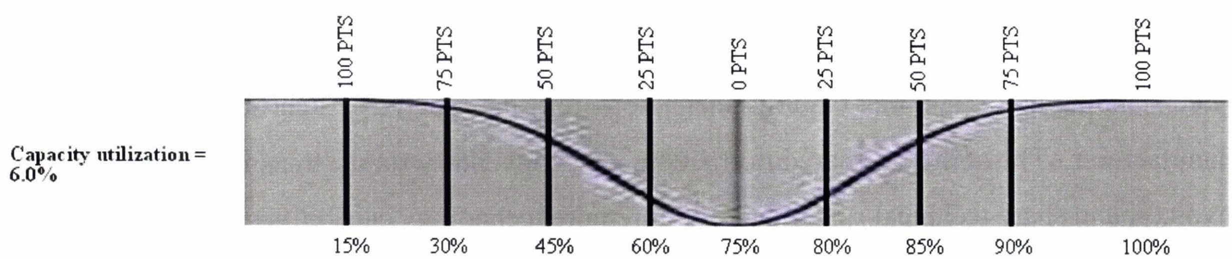



Figure 30: Capacity Utilization

On this scale, 0 risk is associated with a capacity utilization of 75%. To handle demand increases and consolidated spending with suppliers, it is important that strategic suppliers have the capability to absorb additional demand, increased product mix, or provide new value added services . On the scale above, if a supplier has a high utilization (>75%), the risk of using that supplier goes up since consolidation opportunities may be limited. Conversely, if utilization is low (<75%), questions about asset utilization and process efficiency result in a higher risk as well. Therefore, as supplier capability falls further from the "ideal" level, the utility becomes higher.

**Supplier Revenue Represented by PKI**

Finding the balance between having leverage with a supplier and representing too much of their business is a key challenge for many organizations. Limited leverage in an industry supply-shortage situation may result in the inability to influence supply decisions. Representing a large portion of a key suppliers revenue may place an undue burden on the manufacturer should the supplier have financial difficulties. As a result, the scale in Figure 31 is used in the model.

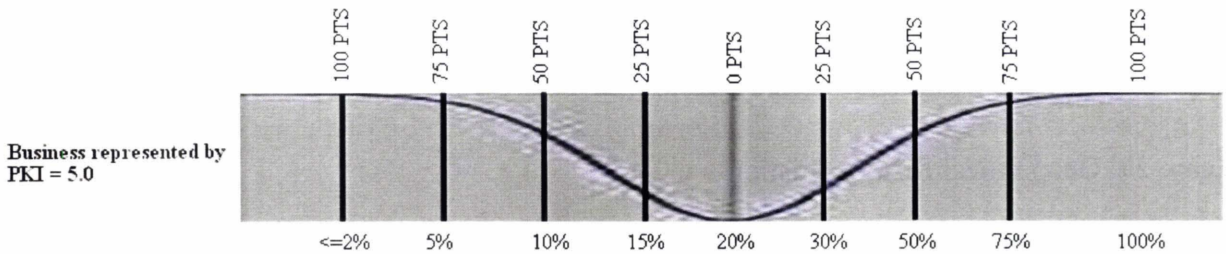



Figure 31: Supplier Revenue Representation

PKI estimates that representing 20% of a supplier's revenue provides leverage in negotiation but does not overexpose the organization.

**Supplier Technology Capability**

Understanding how a supplier employs technology may be a source of significant risk for a manufacturer. The ability to share information, check inventory status, transmit orders, pay invoices, and share technical specifications all require technology capabilities. Using input from the supplier questionnaire, the scale in Figure 32 is used.

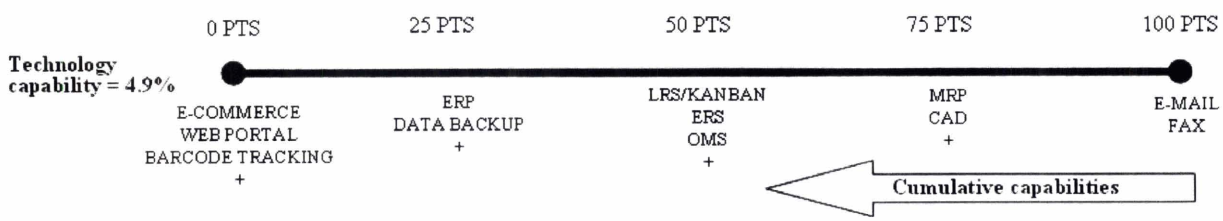



Figure 32: Supplier Technology Capability

In this case, minimal technology capability results in the highest utility score. For each successive capability demonstrated, the utility value is lower. As an example, if a supplier indicates they have e-mail, fax, MRP, CAD, Kanban, Order Management (OMS), and Electronic Invoicing (ERS), but do NOT have an ERP system, they would receive a utility score of 50. Using the weight of 4.9% (as shown in the figure), the individual risk index would be 4.9% * 50 = 2.45.

**Supplier Experience**

For this model, experience has been defined using four (4) criteria; year over year growth for the past 5 years, years in business, years of experience in the part type being sourced, and customer base. Each of these criteria has been assigned its own utility scale and collectively provides the overall utility for the experience risk factor. The scales are shown in Figure 33.

**Experience = 4.3%**

| | 0 PTS | 25 PTS | 50 PTS | 75 PTS | 100 PTS |
|---|---|---|---|---|---|
| **Avg. YOY Growth for past 5 Yrs. = 40%** | >=10% | 5% | 3% | 1 | <=0 |
| **Years in business = 30%** | >=10 | | 5 | | <=1 |
| **Years of experience in the commodity =10%** | >=10 | | 5 | | <=1 |
| **Fortune 500 companies as customers = 20%** | 0 = 0 utility PTS | 1 = 100 utility PTS | | | |

Figure 33: Supplier Experience

Each of the scales is an inverse linear scale, with more experience resulting in lower risk utility. Because PKI is now considering a portfolio of risks, a new supplier to the market that receives a high risk index for this factor and may have been disregarded in the past, may still be chosen based on the overall supplier index. Using the scale above, if a supplier averaged 5% YOY growth, the partial risk index for experience would be 25 pts * 4.3% (factor weight) * 40% (sub-component weight) = 0.43.

**Supplier Organization Structure**

How a supplier organization is structured is important to be able to answer the following questions. First, are they capable of doing business with multiple manufacturing sites on a global scale? Second, do they have the resources in place to handle ad hoc inquires, expedites, or strategic supply issues? Third, do they have the structure in place to handle repair, warranty fulfillment, and other customer satisfaction issues? A supplier who takes ownership of these types of issues provides a partnership opportunity to PKI and reduces the risk of lost customers, lower customer satisfaction, and consumption of valuable time by PKI resources with operational issues. A unique scaling method (shown in Figure 34) was developed for this analysis.

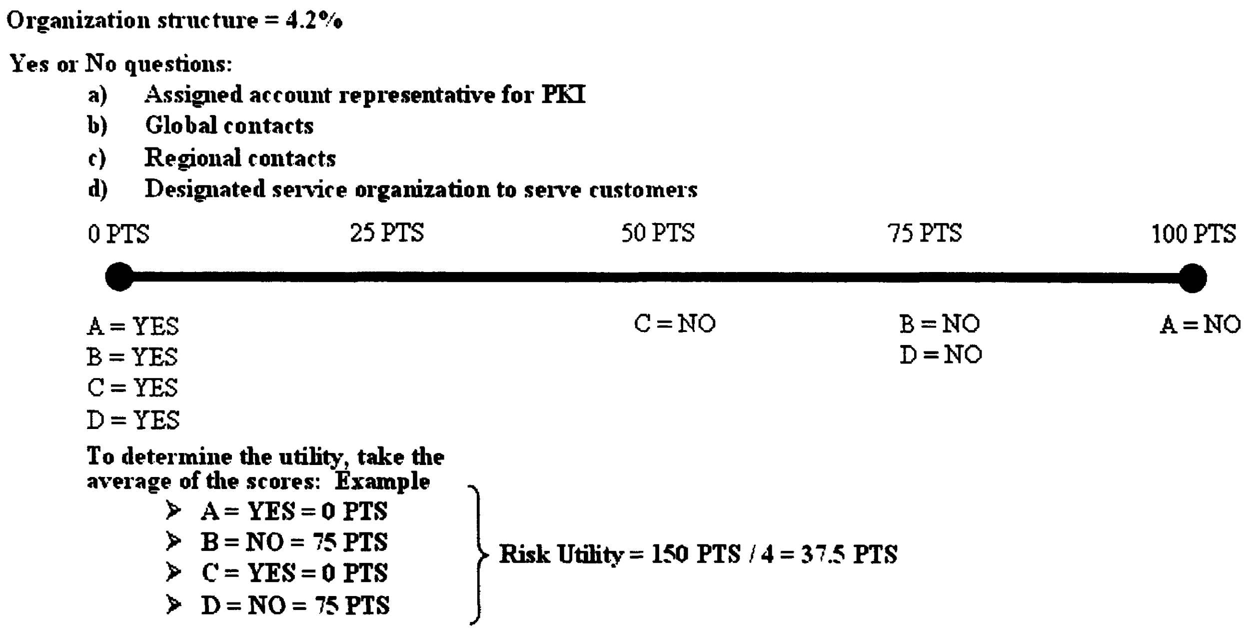



Figure 34: Supplier Organization Structure

By answering the yes/no questions identified, a utility scale can be developed. The utility points associated with each response were determined by SME from the purchasing teams. The example in the figure describes how responses will become the utility score. In the case above, each capability (A through D) is regarded as equally important.

**Supplier Sub-Tier Supply Chain Management**

It is critical to understand how suppliers manage their supply chains and to be involved in understanding the capabilities of Tier 2 and Tier 3 suppliers. Many organizations fail to recognize risk though all tiers of the supply chain and assume suppliers are carrying out their own risk mitigation plans (Kiser and Cantrell 12-17). Using a binary scale, four (4) criteria were considered as indicators of how well a supplier manages their supply chain. Conducting this assessment for a new supplier may be challenging, but is critically important to understand capability to deliver on demand and achieve desired service levels. The four (4) criteria evaluated are 1) does the supplier have a defined purchasing function to deal directly with suppliers, 2) does the supplier have a defined quality engineering team to work through design issues or technical issues with suppliers, 3) can the supplier demonstrate the metrics it tracks for its suppliers (e.g. on-time delivery, quality, etc.), and 4) does the supplier have a disaster recovery plan to ensure continuity of supply within a reasonable amount of time. Positive responses to each of these questions will result in 0 utility points. Based on SME input, each point above varies in importance. Therefore, a methodology was used that a supplier would theoretically start with 100 utility points (maximum) and for each "yes" response that is verified, utility points would be subtracted based on the following scale: defined purchasing function = (40) points, defined quality engineering team = (30) points, supplier metrics = (20) points, and a disaster recovery plan = (10) points. As an example, if a supplier says "yes" to only criteria 1 and 2, the resulting utility score would be 100 – 40 – 30 = 30 utility points.

**Supplier Progressiveness**

Many manufacturers require that suppliers provide cost reductions each year of a contract. However, line of site to those cost reductions is often not apparent. Understanding the focus of the Operations teams and how they value continuous improvement, innovation, training, teamwork, etc. can be indicators of whether or not the supplier is structured to meet the prescribed reductions. Therefore, using a similar method described in the sub-tier management section, five (5) criteria were established to measure supplier progressiveness. Each criteria is listed below with the corresponding utility point reduction (starting with 100 utility points) possible with a "yes" response.

- Formalized 6-sigma program = (25) points;
- Formalized lean manufacturing program = (25) points;
- Formalized safety program = (20) points;
- Formalized 5S program = (20) points;
- Formalized Cross-training program = (10) points.

The variability in point values indicate the relative impact on the overall risk factor.

### 8.2.2 Inventory and Quality Risk

The next three (3) risk subcomponents relate to inventory management and product quality.

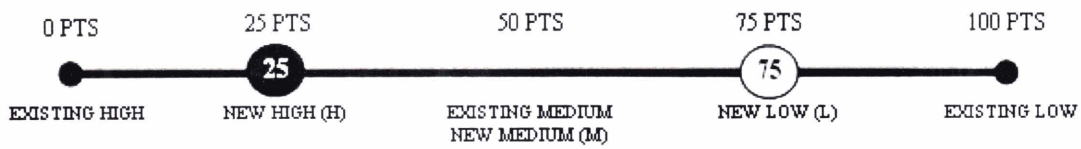
**Product Quality**

Assessing product quality can be done using two processes. First, if a supplier has a history with PKI, the quality engineering team will have data related to defective parts per million (DPPM), yield analysis, cost of poor quality (COPQ), etc. From this data and corresponding internal metrics, the supplier will be given a high (0 utility points), medium (50 utility points), or low (100 utility points) quality rating. However, if a supplier has no history with PKI, a secondary method is used. Using six (6) criteria, DPPM tracking, customer references, yield analysis, warranty processing, delivery performance tracking, and COPQ, a supplier will be evaluated based on their ability to provide evidence that each of the metrics is available to PKI. Furthermore, depending on the type of part being sourced (from section 6.2.2 – HLA, CC, OEM, or STD), the criteria is different. Figure 35 provides the requirements for each type of part. In the figure, an L indicates the *minimum* capability required, an M is considered an *expected but not required* capability, and an H indicates a *nice to have* capability. If a new supplier achieves a high (H) rating, 25 utility points will be assigned. A medium (M) assessment will result in 50 points while a low (L) rating will result in 75 points. It was determined by SME that a new supplier could never be considered *risk free* or *maximum risk* with respect to product quality when no history of interaction exists.

| Evaluation Criteria | HLA | Custom Comp. | OEM Part | Std Part |
|---|---|---|---|---|
| DPPM or rejection rate tracking | L | L | L | L |
| Provide 5 customer references | H | M | H | M |
| Rolling throughput yield analysis | L | L | H | H |
| Warranty data and defined process | M | L | H | H |
| Delivery performance tracking | L | L | L | L |
| COPQ tracking | H | H | H | H |

Figure 35: Supplier Quality Assessment

In order for a new supplier to achieve a high (H) rating, they must demonstrate their capability in ALL criteria, whether low, medium or high. Similarly, to achieve a medium (M) rating, only the low and medium capabilities must be demonstrated. Figure 36 provides two additional examples, using different part types, of how this analysis is performed in the model.




**Example 1: New supplier A to provide HLA**

| Evaluation Criteria | HLA | Answer | Low Criteria | Med Criteria | High Criteria |
|---|---|---|---|---|---|
| DPPM or rejection rate tracking | L | Y | X | | |
| Top 5 customer references | H | Y | | | |
| Rolling throughput yield analysis | L | Y | X | | |
| Warranty data and defined process | M | N | | X | |
| Delivery performance tracking | L | Y | X | | |
| COPQ tracking | H | N | | | |

- Since the medium criteria was not met, the supplier score would revert to the next lower level achieved = New - Low

**Example 2: New supplier B to provide OEM part**

| Evaluation Criteria | OEM | Answer | Low Criteria | High Criteria |
|---|---|---|---|---|
| DPPM or rejection rate tracking | L | Y | X | |
| Top 5 customer references | H | Y | | X |
| Rolling throughput yield analysis | H | Y | | X |
| Warranty data and defined process | H | Y | | X |
| Delivery performance tracking | L | Y | X | |
| COPQ tracking | H | Y | | X |

- Since the low and high criteria were met, the supplier score would be the highest possible = New - High

Figure 36: Product Quality Assessment

### Inventory Management Requirements

Although many costs associated with inventory are captured in the landed cost model, there are other attributes that cannot easily be quantified at the outset of a supply contract. Examples of inventory management considerations include: rework capability, inventory ownership, warranty terms and conditions, returns terms and conditions, packaging characteristics, lead time impact, and inventory position requirements. For each of these considerations, a binary or discrete scaling process is used. Furthermore, since the entire risk factor of inventory management is broken into these considerations, the weight of each (as a part of 100%) is included in the description. The utility scaling methodology for each is described below.

- Rework capability (5%) – If a supplier can rework or repair parts locally (within 1 day ground transportation), there is an inventory and customer service benefit to PKI. Therefore, 0 utility points would be assigned. If the capability does not exist, 100 points are assigned.

- Inventory ownership (20%) – If a supplier is willing to incorporate a vendor managed inventory (VMI) model, there is a reduced risk to PKI for excess, obsolescence, inventory control, and financial accountability. Another alternative is to consign the inventory to PKI where PKI would still manage the inventory, but not pay until the product is consumed. A final alternative is a traditional inventory management process owned by PKI. The resulting utilities for each are: VMI = 0 utility points, consignment = 50 utility points, and traditional inventory management by PKI = 100 utility points.
- Warranty terms (10%) – The risk level is established based on when the warranty offered by a supplier, for a particular part, begins for PKI. The three alternatives are to begin warranty (1) when the part is manufactured, (2) when the product is sold to PKI, or (3) when part is installed in the instrument. The longer the warranty can be delayed, the lower the risk of PKI incurring repair, maintenance, or replacement cost for a customer. Using a similar scale as above, when originally manufactured = 100 utility points, when sold to PKI = 50 points, and when installed in an instrument = 0 points. Currently, the model does not differentiate warranty duration in the risk utility calculation.
- Returns terms (10%) – Risk is determined by whether material is returned for credit or replaced. PKI would prefer that the part be returned for credit as opposed to receiving a replacement or refurbished part for inventory. The risk to PKI in this circumstance is the inability to sell or use a refurbished part in the future, thus leading to obsolete inventory. A binary scale is used, resulting in a utility of either 0 if parts are returned for credit or 100 if the supplier returns a part, whether new or refurbished.
- Packaging (10%) – In an effort to reduce packaging cost and to promote a "greener" organization, being able to reuse packaging materials and maximizing carton capacity is important to PKI. As their global footprint of suppliers expands, encouraging more sustainable shipping processes is a benefit to the entire organization. If packaging is reusable and/or recyclable, the utility score is 0, otherwise, the utility is 100 points.
- Lead time (30%) – Although lead time variability is considered in the inventory levels required to achieve desired service levels, other qualitative risks are associated with longer lead times. Examples of such risks include longer turnaround time for rework or change orders, a higher cost of expediting a shipment given the distance from the manufacturing site,

and reduced flexibility to change lot sizes or order frequency. To assess the lead time risk, the scale in Figure 37 was developed.

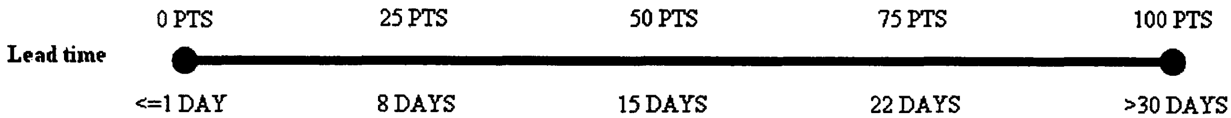



Figure 37: Lead Time Risk Scale

- Inventory position requirement (15%) – Risk is determined by how much inventory is held at the PKI manufacturing site. Although the carrying cost of inventory is included in the landed cost model, there are other risks associated with higher levels of inventory that are more difficult to quantify. Examples include the potential for excess or obsolescence, increased cost of material handling, or a higher likelihood of damaged material. To account for these risks, the scale developed uses the average inventory position of all suppliers being considered for the bid as the "mid-point" or standard (STD) of the scale. As inventory levels vary by supplier, based on lead time, service level, or demand, the risk associated with that supplier can go up or down accordingly. For example, a supplier who is willing to place their inventory close to a manufacturing site, resulting in a reduced inventory requirement for PKI, would be a lower risk for this category. Therefore, as Figure 38 indicates, higher inventory levels, when compared to an "average", equate to higher risk. Conversely, lower levels result in lower risk.

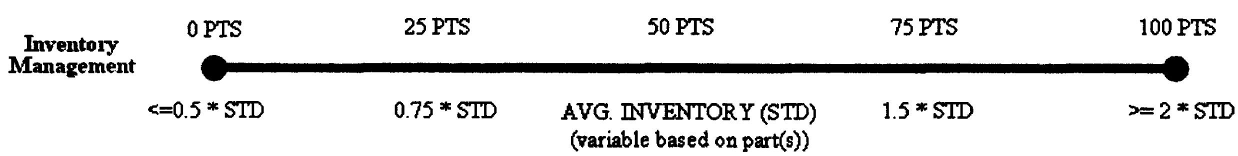
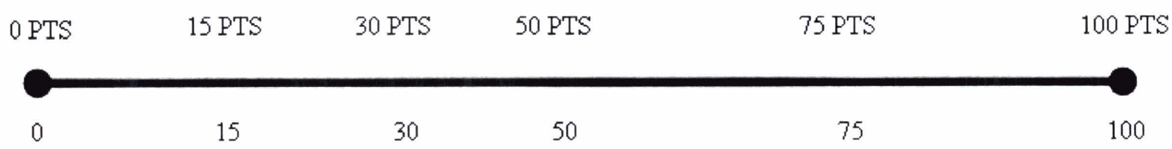



Figure 38: Inventory Position Scale

**Process Quality**

To assess the quality of the operations at a supplier, the model considers several leading indicators that will help understand an organization's dedication to building quality into their processes and thereby into their products. Similar to past scales, the more capability the supplier exhibits, the lower their risk score. Using the figure below, a positive answer and validation for each of the criteria listed results in the risk score being lowered, from the maximum 100, by the value indicated. The figure also shows whether the criteria is considered exceptional (X), high (H), medium (M), or low (L). As is indicated by the criteria, a supplier that is ISO certified would receive 0 risk utility points as it would be assumed that the certification indicates they would also comply with all other criteria. If a supplier is not ISO certified but is ISO compliant, they would achieve a risk utility of 15 points (100-85) in the model. Finally, if a supplier is not ISO compliant, individual criteria that can be confirmed will each reduce the overall utility for the supplier. Figure 39 shows the required calculations and resulting scale.




| Level | Evaluation criteria | Value |
|---|---|---|
| X | ISO certified | -100 PTS |
| H | ISO compliant | -85 PTS |
| H | Work instructions/photo docs | -13 PTS |
| M | Corrective action process | -7 PTS |
| M | Quality manual | -7 PTS |
| M | Calibration/maintenance schedules | -7 PTS |
| M | Data retention | -7 PTS |
| M | Document control | -7 PTS |
| M | Product certifications | -7 PTS |
| L | Control charts/metric tracking | -3 PTS |
| L | Operator metrics | -3 PTS |
| L | Formalized cross-training | -3 PTS |
| L | Quality org reporting is independent of mfg. | -3 PTS |
| L | Inventory segmentation for defects | -3 PTS |

Risk score for a supplier that is ISO certified = 0

Risk score for a supplier that is ISO compliant = 15

Minimum points possible if not ISO certified or compliant = 30

Figure 39: Process Quality Scale

### 8.2.3 Finance Risk

Considering the financial position of a supplier is critical to ensure the sustainability of the organization throughout the duration of the partnership. Unfortunately, many manufacturing organizations scrutinize the financials of their customers, but may not be as diligent with suppliers. Often times, suppliers may encounter financial difficulties and call on their customers for aide with respect to cost increases, payment term changes, or other help to avoid shutting down production. As a result, the model utilizes three finance related measures; financial strength from a third party rating service, local currency volatility, and FDI investment in the economy where the supplier is located.

### Financial Strength

Many institutions utilize services such as Dun & Bradstreet (D&B)[24] to obtain the credit risk associated with a supplier. Using such a service, as well as others, that produces a risk rating (using a 0-10 scale), can provide an indication of the financial risk of doing business with a particular supplier. Realizing that not all companies provide information voluntarily to D&B, the risk rating may not be available. However, understanding the financial position of the supplier using similar criteria as D&B can also be helpful. The model uses the scale in Figure 40 to determine the risk utility points based on risk score.

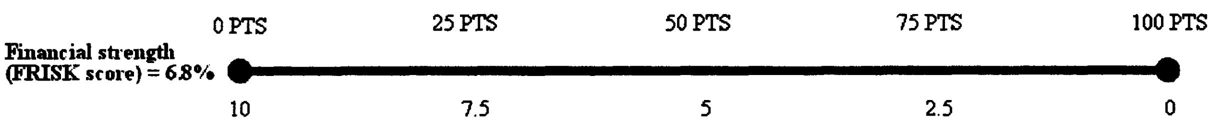



Figure 40: Financial Strength Scale

### Currency Volatility

In the case of PKI, it is likely that most contracts would be negotiated in USD, Euros, or Singapore Dollars. PKI may also choose to hedge against currency fluctuation based on specific contracts. In fact, many models have been developed to consider how exchange rate volatility may impact operations in global manufacturing organizations. Many operational risk models, stemming from significant research, articulate methods for evaluating currency and exchange rate volatility (Huchzermeier and Cohen 100-113; Lessard and Lightstone 107-114; Rosenfield 325-343). Further, investigating the fluctuation of local currencies gives an indication of the stability of the economy where the supplier is located. According to Simchi-Levi, "currency fluctuations pose a significant risk in today's global operations. They change the relative value of production and the relative profit of selling a product in a particular country, taking a business from profitability to total loss (Simchi-Levi, Kaminski, and Simchi-Levi 3rd ed. 316)." Despite contracts being "locked" at a specific rate, the volatility may significantly impact negotiations for

[24] Dun & Bradstreet, Inc Online. Dun & Bradstreet, Inc Company Information. 3 November 2007. <http://www.dnb.com/us/>

future contracts and pricing. If a strong supplier partnership is formed, it may become more costly to change suppliers at the end of a term, thereby subjecting a manufacturer to the market instability. Additionally, a statistical analysis was conducted by Chongcheul Cheong at Kyungpook National University about the impact of currency volatility on international trade. The study was conducted in the United Kingdom and concluded that statistical evidence shows a negative impact on trade with respect to higher exchange rate volatility (Cheong 1-8). Therefore, the model considers the currency volatility, or standard deviation, of over 75 global currencies (against the USD) using a rolling five (5) year period.[25] The volatility is plotted on the lower scale in Figure 41 and the appropriate risk utility determined. As would be expected, lower volatility equates to lower risk.

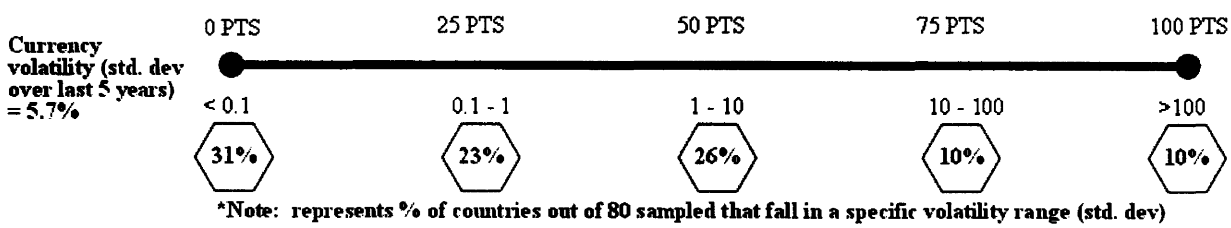



Figure 41: Currency Volatility Scale

**FDI Investment**

As manufacturers consolidate suppliers and source materials globally, many may be conducting business in countries unfamiliar to the organization. However, it is likely that other companies have led the way in researching these countries before making the decision to invest. As a result, the model considers foreign direct investment (FDI) as an indicator of the viability of a country where a supplier may be located. FDI is defined as "the investment to acquire lasting interest in enterprises operating outside of the economy of the investor."[26] If there is significant FDI in a country, that may be considered a positive indicator for conducting business. As a result, using a survey conducted by AT Kearney (ATKearney), over 60 countries were rated and given a tier 1 – 4 rating, based on FDI investment, with a four (4) being very low investment potential. Depending on the country where the supplier will be manufacturing the product, an appropriate

[25] XE Online. 2007. XE Currency Exchange Website. 24 August 2007. http://www.xe.com/ict/.
Historical currency conversion rates can be found at XE.com for any date over the past 13 years. The model uses data from the past five years and takes two data points per year in January and August.
[26] UNCTAD Online. United Nations Conference on Trade and Development Information. 30 August 2007. <www.unctad.org>

"level" is assigned in the model. The level is translated to a risk utility using the scale in Figure 42.

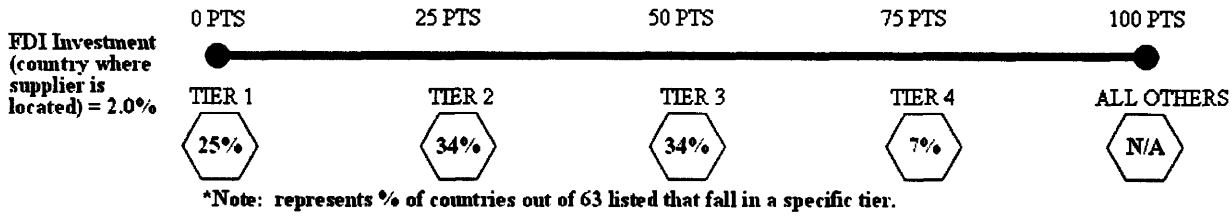



Figure 42: FDI Investment Scale

### 8.2.4 Logistics Risk

Although most logistics related costs are considered in the landed cost model, we identify two additional risk factors. The ability to use PKI preferred carriers and potential supply chain delays are both critical components of the risk model.

**Preferred Carrier Availability**

By using preferred carriers such as FedEx or UPS, PKI ensures that negotiated rates are utilized, quality standards are in place, and that the carrier is reliable to meet projected transit lead times. If a supplier insists upon using another carrier or cannot be reached by a PKI preferred carrier, PKI indirectly assumes the risk for product shipping delays and impact to the operation. As a result, the model uses a binary scale for analysis where the use of a preferred carrier results in 0 utility points while use of a non-preferred carrier carries 100 utility points.

**Supply Chain Delays**

There are many potential supply chain delays that may occur, many of which are covered under previously discussed risk factors, and in terms of lead time variability, directly within the cost model. This particular factor assesses such risk as natural disaster, transportation infrastructure where the supplier is located, capability of a port, or relative proximity to a port, airport, or other transportation hub. A recent article in Purchasing suggests that the rapid expansion of manufacturing and sourcing in Asia is making it difficult for the logistics infrastructure to keep up with the growth of import and export demand. The two most impacted regions in the world, China and Eastern Europe. Also, the article provides data showing that volume in US ports on the West Coast have increased 41% over the past four (4) years. Additionally, environmental controls and regulations continue to play a larger role in supply chain execution (Hannon 78-83). Using a scale similar to that of FDI, each of eighteen global regions are categorized using industry expertise to provide an indication of supply chain risk. Those regions categorized as low risk (e.g. USA, EU countries, Canada, etc.) would receive 0 utility points. Medium risk regions (e.g. Non-EU countries, Japan, Mexico, et.) would receive 50 utility points, while high risk regions (e.g. China, India, Latin America, etc.) would receive 100 utility points.[27]

### 8.2.5 Trade Compliance Risk

Exporting and importing materials can be one of the largest sources of risk facing a manufacturer. Import documentation requirements, proper material coding, customs processes, correct product valuation, country of origin assessment, expected product use, etc. can all be sources of operational delays if proper procedures are not followed by both the exporter and importer. Despite supplier export experience or manufacturer importing experience, delays are still likely to occur. However, experience still provides the best insulation to ensure that product moves smoothly from global supplier to manufacturer. To best assess the risk and challenges in dealing with global suppliers, an assessment scale was developed for the risk model. Using the risk components identified above and the results of the supplier questionnaire on these topics, the scale in Figure 43 is utilized.

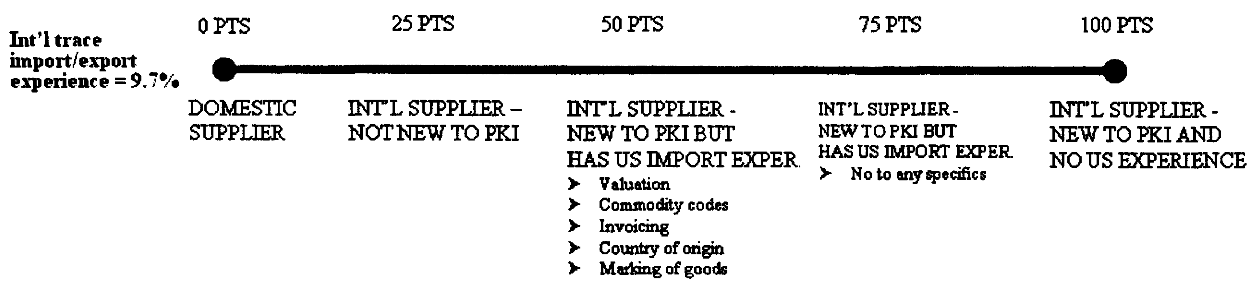



Figure 43: Import/Export Experience

Using the figure above, if a supplier currently conducts business with PKI, the Trade Compliance team is well qualified to provide an assessment of that supplier. However, if the supplier is new to PKI, additional analysis is required. Specifically, five (5) specific export/import compliance capabilities are evaluated.

[27] This assessment is not based on any specific statistical analysis on the likelihood of a particular event, but anecdotal evidence from experience with suppliers in specific regions.

### 8.2.6 Research and Development Risk

A final important risk factor to consider for a supplier is their capability to develop new products and be innovative with existing PKI products. Although other risk factors may be more costly to the current operation, understanding how a supplier will partner with PKI to become more cost effective and provide better instrumentation is identifying future risk. For example, if two suppliers are being considered, a supplier that has R&D capability brings more value to PKI than one that has no capabilities in the area. Leveraging supplier R&D enables PKI to focus on instrument development while supplier expertise is capitalized for part level improvements. To assess this "risk", the model uses four (4) components.

- *Historical customization projects* provide an idea of the capability and magnitude of projects that the supplier can sustain. The model uses an inverse linear scale with no projects resulting in the maximum risk utility and >=10 projects resulting in 0 utility points.
- *Engineering organization* structure gives an indication of dedication to product development. A dedicated team with various engineering skills is evidence of a supplier that will be able to bring additional value to the partnership. 0 or 100 utility points are assigned depending on whether the supplier has a dedicated R&D team.
- A balance of *engineering skills* is also critical for sustained product development capability. For PKI, mechanical and electrical engineering, software and firmware development, and application testing are specific skills that are likely to bring the most value to their products.
- *New product development* has been defined in various stages for the model. Reverse engineering, value engineering, new design/co-development, and full development capability are the measures by which a supplier is evaluated. The more complexity a supplier can manage, the less "risk" they are to PKI for future product development and current product cost reduction. The scale in Figure 44 details how each level of accomplishment yields a reduction from the maximum risk score possible (100 points).

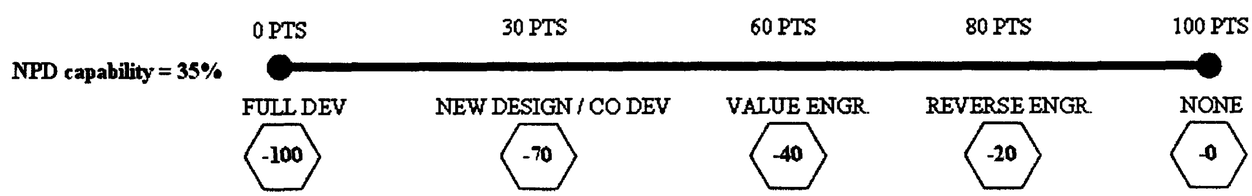



Figure 44: New Product Development Scale

## 8.3 Risk Index Analysis

In order to fully understand the risk index computation, there are four different perspectives that should be considered; overall supplier risk portfolio indices, risk category indices; risk balancing within the portfolio, and individual risk factor indices. A dashboard (Figure 45) reflects the output of the model for each of these perspectives. Each section of the dashboard will be explained in the following sections.

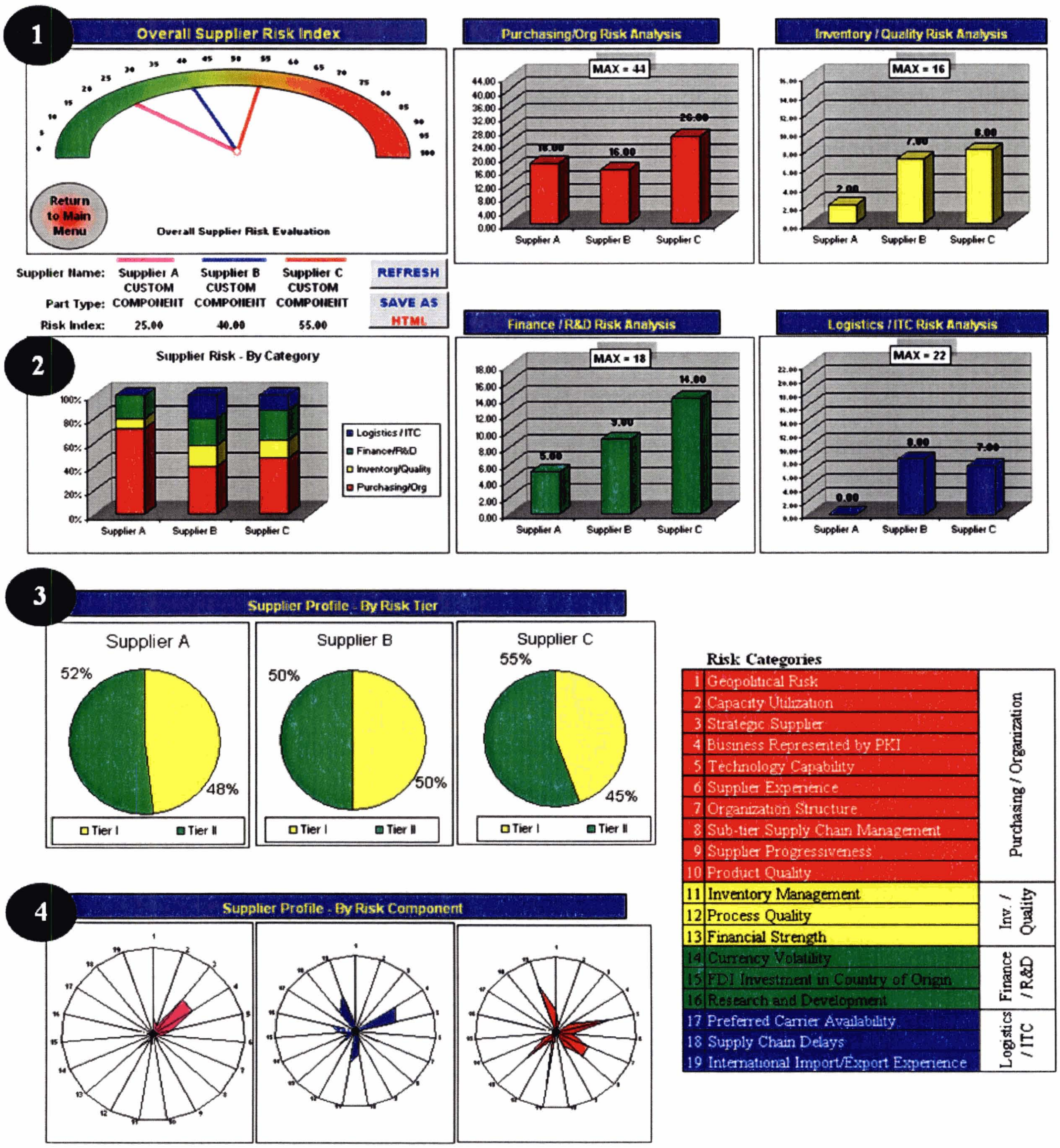



Figure 45: Risk Dashboard

### 8.3.1 Overall Supplier Risk Index

The first section of the dashboard provides a view of the overall supplier risk index based on the utility-weight calculation method. The scenario provided in Figure 45 shows three example suppliers with risk indices of 25.00, 40.00 and 55.00. Although the overall risk index is important, the other three (3) sections of the dashboard provide more information about the composition of the index. The gauge chart provides a pictorial image of the overall supplier risk indices.

### 8.3.2 Risk Indices by Category

The next level of detail provides a breakdown of risks by category. The first graphic displays what percentage of the total risk index is provided by each category. Following, each risk category index is displayed for all suppliers. These five (5) graphs allow the model user to understand the largest risk categories and which ones should be the first to receive more in-depth analysis. In the example, supplier C has a purchasing/organization risk index that is significantly higher than the others. This outcome may prompt PKI to investigate those risk components, develop mitigation strategies, and prioritize improvements to reduce the overall risk to PKI. In addition, the maximum risk possible for each category is displayed at the top of each graph, giving a relative sense of each suppliers risk versus potential risk in the category. Finally, as each supplier's profile (an indication of capability) is updated and maintained in the model, this dashboard can be recalculated to understand how individual improvements reduce overall supplier risk.

### 8.3.3 Risk Indices by Tier

Another section of the dashboard allows overall portfolio composition to be analyzed. Tier 1 and Tier 2 risks have been established, where Tier 1 risks are the top 10 risks in terms of weight in the portfolio. At their maximums, the top 10 risks make up 65% of the total possible risk. Since risk categories and factors spread across Tiers, there is no correlation between the two. Therefore, these views allow the user to understand where the majority of risk originates. If most of the risk comes from the Tier 1, the supplier risks may be quite substantial and could have a significant impact on the business. However, if most of the risk comes from Tier 2, that would indicate there are risk factors present, but may be less impactful.

### 8.3.4 Risk Indices by Individual Factor

The final analysis opportunity comes from viewing the individual risk factor indices. A radar chart provides a simple visual display of those factors that are the single largest contributors to the overall index. On the outside of the radar chart is a number that corresponds to each individual risk factor (also shown in the table next to the charts). Since no single risk factor has a possible rating higher than a 10, the center of the circle represents a 0 index while the outer edge represents an index of 10.[28] As an example, reviewing supplier C, the largest contributors to the risk index are risks 5, 7, 8, 11, 13, and 19, which can be cross-referenced from the list provided in Figure 45. Like each of the prior sections, understanding individual risk factors enables PKI to pinpoint those that are most likely to impact the business. In addition, when partnering with strategic suppliers, this feedback will be invaluable for suppliers to understand what they need to focus on improving to preserve PKI's business.

## 8.4 Chapter Summary

The risk model described above was created to provide a common framework for assessing supplier risk. Quite often, risk is perceived by each operation based on their past experience with a supplier, yet no regular review process of risk is established. By minimizing subjectivity, considering a comprehensive list of risks, and by engaging global SME and customers in the development process, the model provides insight and understanding of risk for any supplier being considered as a sourcing partner. Incorporating financial portfolio principles and balancing the overall risk portfolio, PKI will be better informed about those risks that exist and potential costs to the business. A key component of the model is to utilize input from suppliers which has been validated by PKI purchasing and/or sourcing team members. The results of the questionnaire and model should be reviewed regularly with suppliers as a part of business reviews or scorecard analyses. Encouraging open sharing of information, corrective action plans, and recovery alternatives will provide an opportunity to create more collaborative relationships, ultimately leading to improved responsiveness to customer demand. Understanding risk is a complex yet often over-simplified process. However, the model attempts

[28] The highest weighted single risk component is trade compliance experience. Since it has a weight factor or 9.84% and a maximum utility of 100, the highest component index is 100 * 9.84% = 9.84.

to take a complex algorithm for each calculation and provide meaningful, informative information in the dashboard.

The case study in Chapter 9 will provide additional insight in how the statistics and results of both the landed cost and risk analysis models come together in a final output.

## Chapter 9: Case Study

To convey how the model is used in a specific case, the study that follows provides information about a component that was a candidate for a new supplier. In this situation, suppliers under consideration were located in the United States, Germany, and Singapore. This is a classic example that demonstrates the power of the model and how the outcome provides information that may be counter-intuitive to the expected results. In this case, two (2) transportation scenarios were considered. The two international suppliers (Incumbent and Existing) could utilize either air or ocean shipment while the only option for the domestic supplier (New) was ground shipping. Figure 46 shows the risk model outcome for this case example.

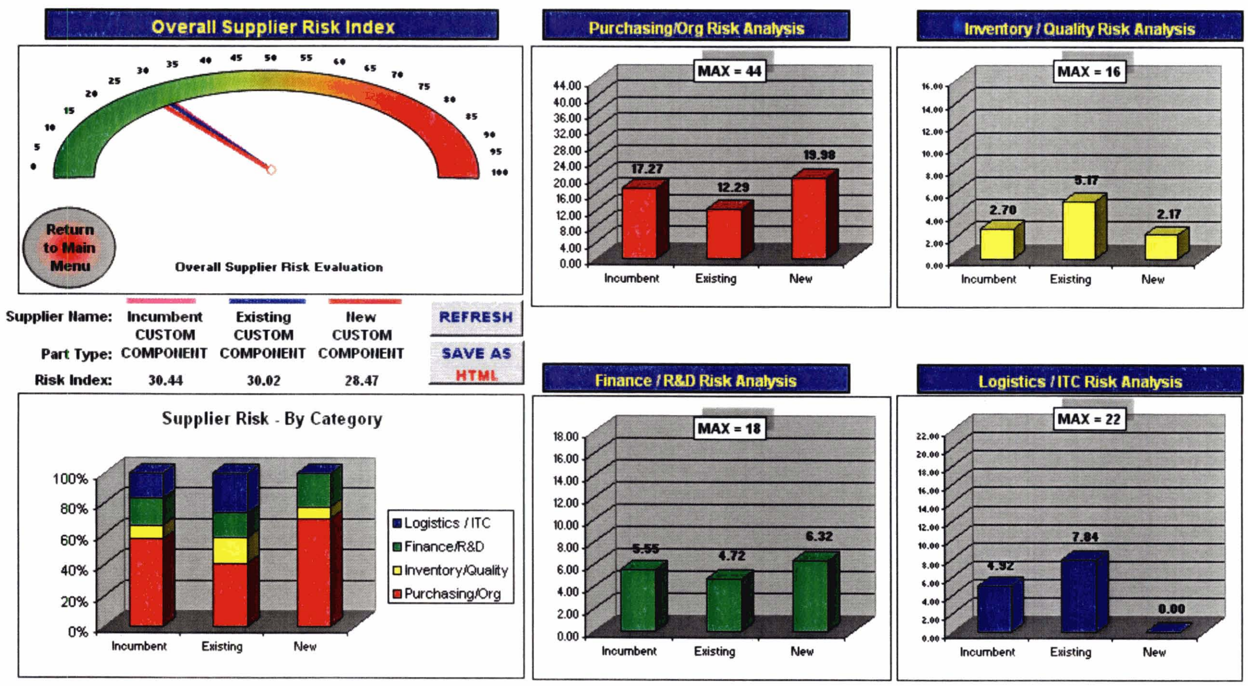



Figure 46: Case Study Output - Risk Dashboard

As the dashboard shows, the relative risk index for each supplier is very similar with values of 30.44, 30.02, and 28.47 respectively for Incumbent, Existing, and New. It is important to ensure that the risk model is run prior to a cost model so an accurate risk-adjusted cost can be calculated. By populating risk profiles in advance, "real-time" supplier negotiations are enabled with the use of the risk dashboard output and landed cost summary. In viewing the risk category data, we can see that Existing has a much higher Logistics/Trade Compliance risk than that of New. One other interesting component of the risk model is that the overall risk for all three suppliers is dominated by Purchasing/Organizational risk factors. Therefore, any material and tooling cost will be the primary cost component driving the risk-adjusted cost. However, since each risk category will be utilized in the risk-adjusted cost calculation as described in Figure 14, logistics, finance and inventory costs all factor into the risk-adjusted cost. For the same suppliers, the Figure 47 shows the landed cost model output.

| | Incumbent | Existing | New |
|---|---|---|---|
| Analysis for Part Number: B1000000 | B1000000 | B1000000 | B1000000 |
| 3 Year Demand Total | 1,350 | 1,350 | 1,350 |
| Evaluation Period (yrs.) | 3 | 3 | 3 |
| HTS/Part Description | Parts of Instruments | Parts of Instruments | Parts of Instruments |
| Shipping Origin | CENTRAL EUROPE | ASIA PACIFIC | NORTHEAST |
| Quote number | Part - A | Part - B | Part - C |
| Summary Over 3 Year Horizon - Scenario 1 | | | |
| Freight Mode | OCEAN | OCEAN | GROUND |
| Freight | 190,267 | 196,662 | 44,542 |
| Inventory Carrying Cost | 16,286 | 9,872 | 2,376 |
| Material Cost | 710,150 | 400,790 | 550,498 |
| Packaging Cost | 0 | 0 | 0 |
| Tooling Costs | 0 | 2,783 | 7,236 |
| Finance Charges | 10,089 | 0 | 0 |
| Material Cost Reductions from Discounts | 0 | 0 | 0 |
| | | | |
| Engineering Qualification | 0 | 0 | 0 |
| Warehouse and One-Time Charges | 5,567 | 5,567 | 0 |
| Assist Cost | 0 | 0 | 0 |
| Assist Duty | 0 | 0 | 0 |
| | | | |
| Total Landed Cost | 932,358 | 615,674 | 604,652 |
| % Savings over Highest Cost Supplier | 0 | 0 | 0 |
| Total Savings over Highest Cost Supplier | 0 | 316,684 | 327,706 |
| PPV Savings over Highest Cost Supplier | 0 | 309,360 | 159,652 |
| Weighted Piece Part Price | 691 | 456 | 448 |
| **Risk Adjusted Cost** | **1,065,495** | **681,542** | **716,161** |
| | | | |
| Summary Over 3 Year Horizon - Scenario 2 | | | |
| Freight Mode | AIR | AIR | GROUND |
| Freight | 512,601 | 499,985 | 44,542 |
| Inventory Carrying Cost | 5,452 | 2,925 | 2,376 |
| Material Cost | 710,150 | 400,790 | 550,498 |
| Packaging Cost | 0 | 0 | 0 |
| Tooling Costs | 0 | 2,783 | 7,236 |
| Finance Charges | 10,469 | 0 | 0 |
| Material Cost Reductions from Discounts | 0 | 0 | 0 |
| | | | |
| Engineering Qualification | 0 | 0 | 0 |
| Warehouse and One-Time Charges | 0 | 0 | 0 |
| Assist Cost | 0 | 0 | 0 |
| Assist Duty | 0 | 0 | 0 |
| | | | |
| Total Landed Cost | 1,238,672 | 906,483 | 604,652 |
| % Savings over Highest Cost Supplier | 0 | 0 | 1 |
| Total Savings over Highest Cost Supplier | 0 | 332,189 | 634,020 |
| PPV Savings over Highest Cost Supplier | 0 | 309,360 | 159,652 |
| Weighted Piece Part Price | 918 | 671 | 448 |
| **Risk Adjusted Cost** | **1,387,242** | **1,027,413** | **716,161** |

Figure 47: Case Study Output - Landed Cost Model

As a note, no currency symbols are utilized in the output since it may represent USD, Euros, or Singapore Dollars.

In this pilot example, Incumbent currently utilizes ocean freight as the preferred mode of transportation (Scenario 1). From the output, it is evident that Incumbent has the highest landed cost and the cost comparison between Existing and New reveals that New has the lowest landed cost. Consequently, the difference between New and Incumbent is approximately $327,000. An interesting outcome of the model is that had the sourcing decision been made on the largest PPV savings over the incumbent, Existing would be selected with a PPV savings of $309,000. However, making the decision based on PPV would reduce the overall savings to PKI by $11,000 ($327,000 - $316,000). Using the risk indices shown in Figure 46, existing provides the lowest risk-adjusted cost of $682,000 compared to $716,000 for New. Therefore, although the overall supplier risk indices appeared relatively similar, the composition of the index dramatically impacted the expected cost of the risk. In this case, the risk cost associated with Existing is approximately $66,000 ($681K - $615K) versus $112,000 ($716K-$604K) for New. Regardless of the model outcome, PKI must make the sourcing decision in the larger context of an overall sourcing strategy. Supplier consolidation, long-term partnerships, supplier location, or individual risk factors will also contribute to the decision. Interestingly, in this example, considering landed cost versus risk-adjusted cost yielded different supplier choices.

The impact of the model is shown more dramatically in scenario two above. In this example, the international suppliers service PKI via air shipments. If the sourcing decision was made using PPV as the driving factor, Existing would still be selected with an overall savings of $327,000. However, considering total cost savings or risk-adjusted cost, the potential savings to PKI is over $630,000 or an additional $303,000 (by selecting New) over the PPV savings.

The risk and cost models provide a diverse set of information for the user community to consider when making strategic sourcing decisions. Utilizing the entire complement of costs, metrics, and risk factors will enable PKI to select suppliers that align both strategically and financially with corporate initiatives.

## Chapter 10: Conclusion and Next Steps

The landed cost and risk model developed for PKI has enabled the organization to take a more complete look at costs and risk associated with sourcing decisions. Rules of thumb about material savings required to compensate for other costs can now be discarded and actual cost differences analyzed. Risk factors that were unknown can now be compared between suppliers using common criteria. Supplier partnerships can be strengthened using the risk model output and ensuing mitigation strategies. Global manufacturing sites can now leverage common supplier information and historical data to make more educated sourcing decisions. Despite these benefits, the most critical success factor for the model is incorporating its use into the standard supplier review and sourcing analysis processes. The change management foundation that has been laid during development must be built upon to encourage use and review of the model with each sourcing decision to realize the value and benefits to the entire organization. Recognizing that using the model is an innovative approach to making sourcing decisions, challenges along the learning curve are expected. However, as metrics and incentives are aligned with using the model, the long-run value of the model will outweigh the short-term implementation challenges. Understanding that appropriate metrics may not exist today, they can be created in the future to help manage risk profiles, risk measures, and bottom-line cost savings (Hauser 64-71).

The model was created as a decision making tool that encourages interaction between suppliers, purchasing agents, sourcing leaders, and support organizations. Accordingly, each team plays a crucial part in the ongoing success of the product. Suppliers must work closely with PKI to reduce risk factors and provide accurate information in quotes. Purchasing agents need to take time to learn how the tool works and become comfortable with the inputs and outputs. Like any software application, time and effort is required to realize the full capability of the tool. Sourcing leaders should work closely within a global team to leverage common suppliers, manage risk profiles, and share results of the model as a means of distributing best practices. Support organizations such as Trade Compliance, Logistics, Finance, and others should be involved with maintaining model datasets such as freight rates, duty rates, corporate financial inputs, etc. The model encourages interaction between groups to leverage individual expertise and recognize risks that fall within the scope of each team.

As stated in the hypothesis, the expected outcome of sourcing in low-cost countries is often a significant savings over domestic suppliers. As demonstrated by the case study presented in this thesis as well as research conducted, material savings is often outweighed by other costs that dramatically increase when utilizing global material sources. This result solidifies the importance of considering the total landed cost with each supplier alternative. When coupled with strategic business objectives, optimal sourcing decisions are made. Further since the model was developed generically for PKI, the concepts are transferable to other companies facing similar global sourcing decisions.

The project also had significant technical aspect associated with it and is a complex relationship between a static data warehouse and dynamic modeling component. To support ongoing development and day-to-day use of the model, a technical manual and work instructions were developed to provide detailed information and processes about the mechanics of the model as well as requirements for how the model should be maintained going forward. The manuals establish owners for application components and the long-term viability of the model will rely on these processes being followed.

There are several next steps that will further enhance the value of the model.

- Establish risk profiles soon by creating supplier capability profiles for top tier suppliers.
- Create a process for reviewing landed cost throughout the contract period so additional cost saving alternatives may be considered.
- Develop a mechanism to capture risk related costs during the contract period to associate with the supplier risk profile and risk adjusted cost. Capturing these costs will begin the process of establishing the efficient risk frontier.
- Construct a cost/benefit analysis (CBA) process for risk mitigation activities. Using the risk-adjusted cost and cost to minimize the risk enables the creation of a CBA to compare the investment required for the mitigation action against the expected financial impact of a risk materializing (Kiser and Cantrell 12-17).

- Conduct a risk management assessment across the company to understand the delta between the current state of risk analysis and preparedness and a desired future state. The five (5) stages of risk management maturity, as defined by de Waart, include 1) risk management is conducted on "gut-feel" 2) risk management is handled at functional levels 3) risk management is a well-defined process and is cross-functional 4) a portfolio of risks is developed and 5) the risk management vision is extended across the entire enterprise (27-33).

In conclusion, the objective of the project was create a flexible, easy to use decision making tool to better understand landed cost and supply chain risk associated with sourcing decisions. With this tool, PerkinElmer now has the capability to more closely partner with suppliers, reduce the risk of operating in a global economy, and improve financial results for the organization.

# Appendices

## Appendix 1 – Definition of Assist[29]

### ASSISTS

What is an assist? An assist is defined as: "Tangible items or foreign engineering given free or at a reduced cost to the foreign supplier, and used in the production of the imported merchandise."

**Types of assists:**

- Materials, components, parts and similar items incorporated in the imported merchandise.
- Tools, dies or molds used in the production of the importer merchandise.
- Merchandise consumed in the production of the imported merchandise.
- Engineering, development, artwork, plans or sketches undertaken other than in the USA which are necessary for the production of the imported merchandise.

**Not an assist:**

- Work is performed by a person domiciled within the USA
- Anything that is incidental to the engineering, development, artwork, designs or plans and is undertaken in the USA.

**Determining the value of assists:**

If the assist occurred in the USA and one or more foreign countries, the value of the assist is the cost of the portion of work done outside the USA.
If the assist was purchased or leased from an unrelated person, the value of the assist is the cost of the purchase or lease.
Selling commissions are considered dutiable and must be included in the value. (A selling commission is paid to a selling agent for the exporter)

**Example of an assist:**

Company X in the USA contracts company Y in Taiwan to produce "South Park" figurines for them. Company X supplies the molds free of charge to company Y and ships them to company Y. The cost of the molds and shipping is $10,000.00 and $500.00, respectively. Company X also supplies drawings of the characters which were produced in the art department of company X. What is the total cost of the assist to be declared to CBP upon importation of the finished figurines?

*Answer:* The total cost of assists would be $10,500.00. The cost of the drawings would not be included in the value of the assists since the drawings were produced by a person domiciled within the USA.

[29] Documentation provided by PerkinElmer Trade Compliance team

# Appendix 2 – Risk Model Questionnaire

| | | | |
|---|---|---|---|
| | **Supplier Name:** | **Notes and Descriptions** | **Survey ID:** |
| **Ref** | | **PURCHASING / ORGANIZATIONAL** | |
| 1 | **Capacity utilization** | What is your current capacity utilization, without the business you are quoting, for the facility where you would consider manufacturing the quoted part(s)? | |
| 2 | **Business represented by PKI** | How much of your total company revenue is represented by PKI business? | |
| 3 | **Experience** | | |
| 3A | Average Year over Year (YOY) growth (last 5 years) | Please provide a percentage as your response (0.10 for 10%) | |
| 3B | Years in business | Years in business for the company - no specific product history | |
| 3C | Fortune 500 companies served | Do you currently have other Fortune 500 companies as customers? | ◉ YES: F 500 ○ NO: F 500 |
| 3D | Years of mfg. experience in commodity quoted | Please keep your response specific to the part(s) being quoted | |
| 4 | **Technology capability** | | |
| 4A | E-mail | For each of the capabilities listed to the left, please indicate whether you do or do not have that technology available at this time. In the comments section, please see the requested verification. Specific descriptions are below. | ○ YES: E-MAIL ◉ NO: E-MAIL |
| 4B | Fax | | ○ YES: FAX ◉ NO: FAX |
| 4C | MRP | MRP = Materials Requirement Planning and would be used to plan production | ○ YES: MRP ◉ NO: MRP |
| 4D | CAD | CAD = Computer Aided Drawing to be used to review drawings | ◉ YES: CAD ○ NO: CAD |
| 4E | Ability to use PKI's Lean Replenishment System (LRS) or a kanban system | LRS = Lean Replenishment System to receive systematic PO's from PKI based on inventory levels. | ○ YES: LRS ◉ NO: LRS |
| 4F | Electronic Receipt Settlement (ERS) | ERS = Electronic Receipt Settlement to enable automatic payment processing | ◉ YES: ERS ○ NO: ERS |
| 4G | Order Management System (OMS) | OMS would allow electronic processing of orders from PKI | ◉ YES: OMS ○ NO: OMS |
| 4H | Enterprise Resource Planning (ERP) System | ERP systems would include SAP, Oracle or others that provide enterprise technology | ◉ YES: ERP ○ NO: ERP |
| 4I | Data Backup | | ◉ YES: BACKUP ○ NO: BACKUP |
| 4J | E-commerce | Do you utilize any e-commerce functionality or have a web-portal that would enable web-based ordering, PO reconciliation, and order tracking? | ◉ YES: E-COMM ○ NO: E-COMM |
| 4K | Web Portal for on-line ordering | | ◉ YES: WEB ○ NO: WEB |
| 4L | Barcode Tracking | | ○ YES: BARCODE ◉ NO: BARCODE |
| 5 | **Organization Structure** | | |
| 5A | Assigned account rep | Will PKI have an assigned account rep to handle questions and inquiries? | ○ YES: REP ◉ NO: REP |
| 5B | Global sales contact | Is there a global sales contact that would assist with consolidating demand/orders from multiple global PKI facilities? | ○ YES: GLOBAL ◉ NO: GLOBAL |
| 5C | Regional sales contact | Is there a regional contact in the area of the PKI factory that will serve as a contact for PKI for order processing? | ○ YES: REGIONAL ◉ NO: REGIONAL |
| 5D | Dedicated service organization | Does the organization have a service organization to handle product repair, customer inquiries, or quality issues? Please comment if the technicians are in the field, on-site or both, contracted or company employees, etc. | ◉ YES: SV. ORG ○ NO: SVC. ORG. |
| 6 | **Sub-tier SC Mgmt** | | |
| 6A | Defined purchasing org | Do you have a purchasing organization (separate organization or combined with other functions) to manage your suppliers and customers? | ◉ YES: PURCH. ORG. ○ NO: PURCH. ORG. |
| 6B | Defined supplier quality org | Do you have a quality team (separate or combined with other functions) that works with supplier to ensure product quality? Could include any Material Review Board (MRB) functions that exist. | ○ YES: SUPPLIER QUAL. ◉ NO: SUPPLIER QUAL. |
| 6C | Examples of supplier metrics | Do you keep metrics on your suppliers? Quality, on-time delivery, etc. | ○ YES: SUP. METRICS ◉ NO: SUP. METRICS |
| 6D | Defined disaster recovery plan | Do you have a **documented** disaster recovery plan? | ○ YES: DRP ◉ NO: DRP |
| 7 | **Supplier Progressiveness** | | |
| 7A | 6-sigma program | As PerkinElmer continues to grow, we are interested in how our suppliers will grow, scale, and reduce costs with us in the future. Please indicate whether these programs are utilized in your organization. | ○ YES: 6-SIGMA ◉ NO: 6-SIGMA |
| 7B | Implemented and using Lean principles | | ◉ YES: LEAN ○ NO: LEAN |
| 7C | Active 5S program | | ◉ YES: 5S ○ NO: 5S |
| 7D | Formalized safety program | | ◉ YES: SAFETY ○ NO: SAFETY |
| 7E | Cross training and education plans for employees | | ◉ YES: X-TRAINING ○ NO: X-TRAINING |
| | | **INVENTORY / QUALITY** | |
| 8 | **Product Quality** | | |
| 8A | DPPM or rejection rate tracking | How does your organization build quality into processes? What data and measures do you take to track product quality? Please indicate whether you have the capabilities listed on the left in your organization. Cost of Poor Quality (COPQ) refers to your ability to apply a cost to your business of defective parts or from quality issues identified internally or from customers. | ○ YES: DPPM ◉ NO: DPPM |
| 8B | Yield analysis | | ○ YES: YIELD ◉ NO: YIELD |
| 8C | Historical warranty data / part failure rates and/or defined returns processes | | ◉ YES: WRNTY DATA ○ NO: WRNTY DATA |
| 8D | Delivery performance tracking (OTD) | | ○ YES: OTD ◉ NO: OTD |
| 8E | COPQ tracking | | ◉ YES: COPQ ○ NO: COPQ |
| 9 | **Inventory Processes** | | |
| 9A | Rework parts locally (within 1 day ground transport) | Can you rework parts locally to the PKI site where you are shipping quoted parts? | ○ YES: LOCAL ◉ NO: LOCAL |
| 9B | Inventory ownership | Who will own the inventory in the relationship? | ○ VMI ◉ CONSIGNMENT ○ PKI OWN |
| 9C | Warranty terms | When will the warranty period begin? At manufacture date, install to the instrument date, or a sale to final customer date. | ○ INSTALL ○ SALE ◉ MFG |
| 9D | Packaging (A) | Will packaging be reusable (e.g. carts, racks, etc.) or disposable (e.g. boxes)? | ○ REUSABLE PKG ◉ STANDARD PKG |
| 9E | Packaging (B) | Will you be shipping individual parts or an assembly? | ○ PKG AS AN ASSEMBLY ◉ INDIVIDUAL PARTS |
| 10 | **Process Quality** | | |
| 10A | ISO certified | Please indicate which of the capabilities listed on the left you have to ensure process quality. | ○ YES: ISO CERTIFIED ◉ NO: ISO CERTIFIED |
| 10B | ISO compliant | | ○ YES: ISO COMPLIANT ◉ NO: ISO COMPLIANT |
| 10C | Work instructions/photo docs | | ◉ YES: WORK INSTRUC. ○ NO: WORK INSTRUC. |
| 10D | Formalized corrective action process (CAP) | | ○ YES: CAP ◉ NO: CAP |
| 10E | Formalized document control processes | | ◉ YES: DOC CNTRL ○ NO: DOC CNTRL |
| 10F | Inventory segmentation for defects | | ◉ YES: INV. SEGMENT ○ NO: INV SEGMENT |

| | | | |
|---|---|---|---|
| | **LOGISTICS and TRADE COMPLIANCE** | | |
| 11 | **Preferred Carrier Available** | Are Fed Ex, UPS, TNT, etc. (major courier services) available at your shipping location | ◉ YES: PREFERRED ○ NO: PREFERRED |
| 12 | **Import/Export Experience** | | |
| 12A | Valuation of shipments | Please indicate if you have import and export experience with the subjects listed on the left. Marking of goods | ◉ YES: VALUATION ○ NO: VALUATION |
| 12B | Use of commodity codes | | ◉ YES: COMM CODE ○ NO: COMM CODE |
| 12C | Invoicing for international shipments | | ◉ YES: INVOICING ○ NO: INVOICING |
| 12D | Determining country of origin | | ◉ YES: COUNTRY ○ NO: COUNTRY |
| 12E | Marking of goods based on customer specifications | | ◉ YES: MARKING ○ NO: MARKING |
| | **R&D** | | |
| 13 | **New Product Development/R&D Capability** | | |
| 13A | R&D engineering capability | Does your organization have R&D capability? | ◉ YES: R&D CAPABILITY ○ NO: R&D CAPABILITY |
| | *Skill sets available:* | | |
| 13B | Mechanical engr. | If you have R&D capability, please indicate which skill sets are available within your R&D team. | ◉ YES: ME ○ NO: ME |
| 13C | Electrical engr. | | ◉ YES: EE ○ NO: EE |
| 13D | Firmware development | | ◉ YES: FIRM DEV. ○ NO: FIRM DEV. |
| 13E | Hardware development | | ◉ YES: HARDWARE DEV. ○ NO: HARDWARE DEV. |
| 13F | Application testing | | ◉ YES: APP. TESTING ○ NO: APP. TESTING |
| | *New product development capability:* | | |
| 13G | None (1) | Please indicate the highest level of product development capability you have within your organization. None = 1 up to 5 = full development capability. | ○ NONE |
| 13H | Reverse engineering existing parts (2) | | ○ REVERSE ENGINEERING |
| 13I | Value engineering (3) | | ◉ VALUE ENGINEERING |
| 13J | New design or co-develop new products (4) | | ○ NEW DESIGN AND/OR CO DEVELOPMENT |
| 13K | Full development of new products (5) | | ○ FULL DEVELOPMENT |

# Appendix 3 – Example Costs Represented in Cost Model

For each risk included in the model, a number of potential "costs" represented. These "costs" are the basis for determining the *risk-adjusted* cost.

| | Category | Risk | Definition | What Cost it Covers - Examples |
|---|---|---|---|---|
| 1 | Trade Compliance | International trade import/export experience | Potential delays due to supplier inexperience dealing with customs import/export requirments | "hand holding" suppliers through initial shipments to ensure compliance, documentation training for suppliers, training for PKI employees, shipment discrepancy resolution, potential operational delays if materials are held a customs or ports due to incorrect documentation, non-tariff trade barriers |
| 2 | Purch. / Organizational | Geo-political risk | Changes in political involvement or stability of a country where suppliers are impacted in their ability to do business with international customers | risk of material delay or operational shutdown for a period of time, "cost of doing business" at customs or ports, threat of political changes to foreign trade practice that could impact material flow |
| 3 | Finance | Financial strength | What would happen if a supplier struggled financially and could no longer meet the obligations of the contract | cost of dual outsourcing, last minute supplier search or qualification to maintain supportability, shifting equipment to a new supplier, higher cost when having to alternate source in the short term |
| 4 | Inventory / Quality | Supplier product quality | Cost to correct poor quality materials | cost of rework, customer satisfaction, warranty processing, returns, etc. |
| 5 | Purch. / Organizational | Capacity utilization | The ability of a supplier to react to additional demand. | find other sourcing alternatives, customer lead time changes, temporary inventory shortages, not being able to give the supplier additional products |
| 6 | Inventory / Quality | Inventory requirements | How will inventory be managed and owned between the supplier and customer | obsolete, rework, excess, etc that is NOT included in cost of inventory - result of lead time, culture, etc. |
| 7 | Logistics | Preferred carrier availability | Whether or not a customer preferred carrier is available to service the supplier | rate differential, quality, reliability, leveraging spend, etc. |
| 8 | Logistics | Supply chain delays | A very high level description that would cover such events as a natural disaster, inferior logistics infrastructure, or inadequate shipping capacity at a suppier | supply delays, transportation team involvement, inquiries, claims, discrepancies, problem resolution, etc. |
| 9 | Finance | Currency volatility | Despite contract stipulations of using USD, EU, or other currency, understanding how the local currency of the supplier may impact future contracts or pricing structures | price increases, operating expense, LTA default, etc. |
| 10 | Purch. / Organizational | Strategic supplier/LTA | An assessment of whether the supplier has the capability to be considered strategic or has the capacity to take on additional parts or sourcing opportunities | future supplier selection, renegotiation, lost cost leveraging, contract management, etc. |
| 11 | Purch. / Organizational | Supplier business represented by PKI | If PKI represents a very small portion of the suppliers reveunue, it is possible that in times of supply constraint, PKI may not receive the top priority of the supplier | opportunity cost to find dual sourcing, resolve shortages issues or expedites from supplier, supplier financial difficulties, etc. |
| 12 | Purch. / Organizational | Supplier technology | The possibility that PKI has to conduct business "manually" versus through sufficient technology | manual processing, data transmission errors, data interpretation, communication issues, etc. |
| 13 | Purch. / Organizational | Limited experience and incumbency | The time and effort associated with bringing a supplier up to speed on PKI products, requirements, specifications, etc. | risk of unknown supplier, lack of experience with PKI, data transaction structure not in place, or other costs with supplier changes, etc. |
| 14 | Purch. / Organizational | Supplier organization structure | The possibility that a supplier cannot provide the support structure to PKI to resolve discrepancies, provide global supply visibility, help consolidate spend, etc. | ability to interact for questions, data, managing PKI parts, expedites, bill paying, etc. that can vary based on supplier purchasing and finance team structure |
| 15 | R&D | New product development capability | A differentiator between suppliers that may or may not be able to partner with PKI to improve products or take on an ODM role for PKI | DFM, DFA, innovation, sharing engineering resources to defray cost, etc. |
| 16 | Purch. / Organizational | Supplier supply chain management | If a supplier does not manage their supply chain carefully, upstream delays could ultimately lead to product shortages at PKI | Delays associated with a supplier supply chain and how PKI would be impacted if there was a part shortage |
| 17 | Inventory / Quality | Process quality | The cost of defects to PKI if a supplier does not build quality directly in to their processes | cost of quality, rework, learning curve, etc. |
| 18 | Purch. / Organizational | Supplier progressiveness | The ability of a supplier to reduce costs and scale with PKI | how will they scale cost with PKI, how will they meet productivity improvements, disaster recovery, etc. |
| 19 | Finance | FDI investment | | leverage other company investment research in a country where a supplier is located. Could be indicative of opportunity to expand supplier network there or to stay away for any number of reasons |

## Appendix 4 – Multi-part Quote Comparison Model

If multiple suppliers are quoting on a "family" of parts, PKI may decide to source the entire family to one supplier, or select the low cost supplier for each individual part. The steps for utilizing the template are listed below.

1. Enter the landed cost for each part in the "family" for each supplier
2. Review the combined quote at the bottom of the template for the following output
    a. Total "family" landed cost;
    b. Lowest possible cost by selecting the low cost supplier for each part;
    c. Supplier selection for each part to achieve the lowest total landed cost (green highlight);
    d. Potential savings between single sourcing the "family" and selecting the low-cost supplier for each part.

**Quote Package Comparison Template**

| RETURN | Create a Pkg Quote Number | Supplier 1 | Supplier 2 | Supplier 3 |
|---|---|---|---|---|
| Part # 1 | Part Description | $10 | $5 | $8 |
| Part # 2 | Part Description | $10 | $5 | $8 |
| Part # 3 | Part Description | $10 | $5 | $8 |
| Part # 4 | Part Description | $10 | $5 | $8 |
| Part # 5 | Part Description | $10 | $5 | $8 |
| Part # 6 | Part Description | $10 | $5 | $8 |
| Part # 7 | Part Description | $10 | $5 | $8 |
| Part # 8 | Part Description | $15 | $40 | $25 |
| Part # 9 | Part Description | $15 | $40 | $25 |
| Part # 10 | Part Description | $15 | $40 | $25 |
| Part # 11 | Part Description | $15 | $40 | $25 |
| Part # 12 | Part Description | $15 | $40 | $25 |
| Part # 13 | Part Description | $15 | $40 | $25 |
| Part # 14 | Part Description | $20 | $18 | $17 |
| Part # 15 | Part Description | $20 | $18 | $17 |
| Part # 16 | Part Description | $20 | $18 | $17 |
| Part # 17 | Part Description | $20 | $18 | $17 |
| Part # 18 | Part Description | $30 | $32 | $31 |
| Part # 19 | Part Description | $30 | $32 | $31 |
| Part # 20 | Part Description | $30 | $32 | $31 |
| Total Package Cost | | $330 | $443 | $367 |
| Optimal Configuration Cost | | $180 | $35 | $68 |
| Package Total Using Optimized Cost | | | $283 | |
| Savings Over Lowest Package Cost | | | $47 | |

## Appendix 5 – Data Elements Required for Landed Cost Model

- Supplier name
- Part number
- HTS description
- Hazardous material status
- Instrument where part will be installed
- Part cost
- Mfg country of origin
- Finished goods ship from location
- Freight mode
- Replenishment lead time
- Freight terms
- Shipment type (box, container, pallet, etc.)
- Freight type (Economy, Priority, Express, etc.)
- Is freight or duty paid by supplier?
- Carton dimensions
- Carton or part weight
- Packaging cost (if not included in the part cost)
- Carton capacity
- Order frequency
- Payment terms
- Discount alternatives
- Assist value (if applicable)
- Tooling value (if applicable)
- One time charges (if applicable)
- Warehouse fees (if applicable)
- Engineering qualification requirements (if applicable)

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