STRATEGIC COMPONENT SOURCING IN DISTRIBUTED SUPPLY CHAIN

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ABSTRACT

STRATEGIC COMPONENT SOURCING IN A DISTRIBUTED SUPPLY CHAIN

Manufacturing - large or small - requires components that go through a certain process for conversion to finished goods, which are the source of profit for them. The new paradigm of supply chain is distributed and diverse, spanning over continents, covering different regions, cultures, and government regulations. These days supplier selection is the most strategic decision that an OEM needs to make in order to get the most benefit from the distributed supply chain. Manufacturing in different verticals such as hi-tech, semiconductors, retail consumer goods etc. spends countless man-hours over sourcing decisions.

For companies to implement strategic sourcing they need to focus not just on optimizing numbers but also on the business process of identifying best suppliers for components. Small percentage savings in component sourcing results in significant percentage in the company’s profit. In this project an approach to sourcing utilizing an optimization algorithm will be presented along with a proposed business process for the implementation plan.

The research for this project is conducted with one team member working at Tango Systems Inc. as a Business Analyst.

By
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Syed Asim
**TABLE OF CONTENTS**

1 Introduction ........................................................................................................... 1  
1.1 Background ........................................................................................................... 1  
1.2 Hypothesis ............................................................................................................ 1  
1.3 Problem Statement ............................................................................................... 2  
2 Sourcing Optimization .............................................................................................. 3  
3 Literature Review .................................................................................................... 5  
4 The role of Strategic sourcing in a Supply Chain .................................................... 7  
5 Tango Systems Inc. ................................................................................................... 7  
  5.1 Tango Systems Axcela Tool .................................................................................. 10  
  5.2 Supplier Approval ............................................................................................... 17  
  5.3 Purchasing Data ................................................................................................. 20  
  5.4 New Suppliers .................................................................................................... 20  
  5.5 Production and Service Provision ....................................................................... 21  
6 Mathematical Model ................................................................................................ 24  
  6.1 Supply chain management .................................................................................... 24  
  6.2 Iterative solution .................................................................................................. 31  
  6.3 Implementation .................................................................................................... 32  
  6.4 Solution Behavior in Different Demand scenarios ................................................. 39  
7 Economic Justification ............................................................................................. 42  
  7.1 Executive Summary ............................................................................................ 42  
  7.2 Problem Statement ............................................................................................. 44  
  7.3 Solution and Value Proposition .......................................................................... 49  
  7.4 Market Size ......................................................................................................... 50  
  7.5 Competitors ........................................................................................................ 52  
    7.5.1 JDA ............................................................................................................. 52  
    7.5.2 ARIBA ........................................................................................................ 53  
    7.5.3 MANHATTAN ASSOCIATES ..................................................................... 53  
  7.6 Potential Customers ............................................................................................ 53  
  7.7 Cost Analysis of the Company ............................................................................ 54  
  7.8 Price Point .......................................................................................................... 57  
  7.9 SWOT Analysis ................................................................................................... 59  
  7.10 Investment Capital Requirement ........................................................................ 60  
  7.11 Personal ............................................................................................................. 62  
    7.11.1 Chief Executive Officer ............................................................................... 63  
    7.11.2 Vice President of Sales and Marketing ....................................................... 63  
    7.11.3 Vice President of Engineering .................................................................... 63  
    7.11.4 Human Resources ...................................................................................... 64  
    7.11.5 Accountant .................................................................................................. 64  
    7.11.6 Product development engineer .................................................................... 64  
    7.11.7 Quality Assurance Engineer ....................................................................... 64  
    7.11.8 Consultant Engineer .................................................................................... 65  
  7.12 Business and Revenue Model ........................................................................... 65  
  7.13 Strategic Alliances/Partners ............................................................................... 68  
  7.14 P&L .................................................................................................................. 68
7.15 Return On Investment (ROI) .......................................................... 69
7.16 Exit Strategy ................................................................................. 69
References .......................................................................................... 70
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bullwhip effect</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Objectives of Strategic Sourcing</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Axcela 200/300 System</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>Customer Base of Tango</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>Production Floor Material Floor Chart</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>Tool Capabilities</td>
<td>11</td>
</tr>
<tr>
<td>7</td>
<td>Axcela Tool</td>
<td>11</td>
</tr>
<tr>
<td>8</td>
<td>Tool Screen</td>
<td>12</td>
</tr>
<tr>
<td>9</td>
<td>Wafers</td>
<td>13</td>
</tr>
<tr>
<td>10</td>
<td>Targeted Applications</td>
<td>14</td>
</tr>
<tr>
<td>11</td>
<td>MEMS</td>
<td>16</td>
</tr>
<tr>
<td>12</td>
<td>Under Bump Metallization</td>
<td>17</td>
</tr>
<tr>
<td>13</td>
<td>Vendor Approval Form</td>
<td>19</td>
</tr>
<tr>
<td>14</td>
<td>Manufacturing Flow</td>
<td>21</td>
</tr>
<tr>
<td>15</td>
<td>Sources of traceability of components</td>
<td>23</td>
</tr>
<tr>
<td>16</td>
<td>Changes in the structure of the supply chain</td>
<td>45</td>
</tr>
<tr>
<td>17</td>
<td>Network like model of supply chain</td>
<td>46</td>
</tr>
<tr>
<td>18</td>
<td>Spending and net profit as % of revenue</td>
<td>47</td>
</tr>
<tr>
<td>19</td>
<td>Strategic sourcing impact on Costs, Income, and Market Value</td>
<td>48</td>
</tr>
<tr>
<td>20</td>
<td>Worldwide semiconductor revenues</td>
<td>50</td>
</tr>
<tr>
<td>21</td>
<td>Aerospace Industry Sales</td>
<td>51</td>
</tr>
<tr>
<td>22</td>
<td>Regional distribution of Global Procurement</td>
<td>52</td>
</tr>
<tr>
<td>23</td>
<td>Projected Fixed Costs per year</td>
<td>57</td>
</tr>
<tr>
<td>24</td>
<td>Yearly Profit/Loss Estimate</td>
<td>62</td>
</tr>
<tr>
<td>25</td>
<td>Forecasted Return on Investment</td>
<td>67</td>
</tr>
</tbody>
</table>
LIST OF TABLES

Table 1: Variables for the nonlinear equation ................................................................. 25
Table 2: Projected Fixed Costs for the company ............................................................... 56
Table 3: Variable cost per quarter per customer ............................................................... 57
Table 4: Pricing Strategy for software and services ......................................................... 58
Table 5: Quarterly Profit and Loss estimates ................................................................. 61
Table 6: Projected balance sheet ..................................................................................... 67
Table 7: Projected Profit and Loss .................................................................................... 68
LIST OF EQUATIONS

Equation 1: Linear Equation for supply chain ................................................................. 26
Equation 2: Supply chain constraint 1 .............................................................................. 26
Equation 3: Supply chain constraint 2 .............................................................................. 27
Equation 4: Supply chain constraint 3 .............................................................................. 27
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1 Introduction

The global manufacturing industry is changing such that the Original Equipment Manufacturers (OEM’s) are requiring the component suppliers to be part of value chain and be innovative instead of being just low cost suppliers. The OEM’s are finding that working closely with their suppliers and contract manufacturers can give them a competitive edge. Strategic component sourcing is considered as a part of supply chain management. Modern distributed enterprises have invested heavily in optimizing the component sourcing process and are emerging with innovative approaches to solve the problem of strategic component sourcing.

1.1 Background

Strategic component sourcing involves following general steps:

1. Look at current sources of components used by the company.
2. Detailed cost analysis of available suppliers.
3. Identify the best suppliers.
4. Setup of the new supply structures.
5. Continuous improvement to further optimize the results

1.2 Hypothesis

We are working with an innovative bay area electronic manufacturing company named Tango Systems Inc. They develops, manufactures, markets and services advanced PVD sputtering systems used for high volume manufacturing of flip chip and wafer level chip scale packaging (Tango Systems, 2011). We intend to develop an optimized sourcing
model which will provide cost savings in terms of reduced inventory and faster response time to customer needs.

The optimization of the inventory model will be implemented using excel macros. The optimization model can then be sourced to other OEMs. The model will be vertical independent i.e. with minor modification the model can be applied to non hi-tech manufacturers.

1.3 Problem Statement

Demand variability increases as the industry is further away from the consumer as shown in the figure below. This phenomenon is known as “Bullwhip effect”.

![Figure 1: Bullwhip effect](image)

Source: (Kellogg, 2011)

“The bullwhip effect on the supply chain occurs when changes in consumer demand causes the companies in a supply chain to order more goods to meet the new demand. The bullwhip effect usually flows up the supply chain, starting with the retailer, wholesaler, distributor, manufacturer and then the raw materials supplier. This effect can be observed
through most supply chains across several industries; it occurs because the demand for goods is based on demand forecasts from companies, rather than actual consumer demand.” [1] Lack of information sharing can cascade through the supply chain. This results in small variations in customer demands forcing OEMs to order more from their suppliers. Small changes at retail level lead to huge swings at manufacturing, like a bullwhip. Several retailers order all at once, distributor thinks sales have jumped, orders a much bigger order, etc. Strategic Sourcing can help make intelligent decision in order to reduce the impact of bullwhip effect. Some common strategies to reduce the impact of the bullwhip effect are

- Continuous improvement in learning the effects in the supply chain
- Ability for one stage in the supply chain to see information at other stages.
- Allowing different stages to react to local situation rather trying to identify the root causes.
- Aligning goals and incentives to all the partners in the supply chain
- Reducing lot sizes
- Reducing replenishment lead times
- Building strategic partnerships.

Thus since original equipment manufactures are further away from the customers, managing the volatility in the business is important for them.

2 Sourcing Optimization

Organizations have the goal of developing a strategy that will help them achieve their objectives. Manufacturing organizations, especially original equipment manufacturers (OEM’s) are finding it more difficult to manage the details of the strategy as the process is
more globalized than ever before. Improperly managed sourcing strategy can introduce several intermediary expenses that will wipe out the expected benefits of a global sourcing strategy. Hence it is critical that the strategies are well studied and managed. Sourcing optimization is important as it can significantly reduce cycle time; enable cost savings and guide to a best overall total value management sourcing decision.

**Figure 2: Objectives of Strategic Sourcing**

Source: (Strategic Sourcing 2011)

Sourcing optimization can be defined as follows:

“Sourcing optimization is the rigorous application of well defined analytical techniques to a well defined scenario to arrive at an optimal results out of many which is repeatable”

[Strategic Sourcing Decision Optimization]

Rigorous Analytical Techniques:

The techniques that are applied to problem solving are sound and provable. Use of mixed integer linear programming is one approach to achieve that.
Well Defined Scenario:

The sourcing model must be well defined. This means that it must contain all the direct and indirect inputs, which can be used in the mathematical analytics.

Optimal Decision:

A path to sound decision is important. In many cases the best solution is not the optimal solution. The model and its application will result in a sound optimal decision within defined boundaries.

“Cost reduction is typically the primary goal of most Strategic Sourcing initiatives, because savings in cost of goods sold (COGS) fall directly to the bottom-line. For example, let’s assume that a business reduces COGS by $1 million. If that business has a 10% margin on sales, it must sell $10 million worth of products to achieve the same $1 million in reductions or savings. Again, every dollar from reducing COGS comes directly off of the bottom-line. This is critical in a business environment where it is more difficult to increase revenues.” [Strategic Sourcing]

3 Literature Review

The topic of sourcing component has been addressed by many researchers and book writers. We have reviewed credible books, research papers, thesis, and white papers to understand various aspects in the design of our project. Our topics range to theoretical background of mathematical modeling in Supply chain management [Crespo Marquez, Adolfo (2010)] that provides framework for the distributed supply chain
modeling and its relationship to strategic component sourcing. [H. Edwin Romeijn, Jia Shu, Chung-Piaw Teo (2006)], [V.R. Ghezavati, M.S. Jabal-Ameli, A. Makui (2009)], and [Jean-François Be´rube, Jean-François Be´rube, Jean-Yves Potvin (2007)] takes a classical supply demand problem and propose an approach for solving it efficiently under certain constraints. The information and know how from these is used in understanding the fundamental working of optimization problem with emphasis on Supply Chain management taking in to account which variable needs to be monitored in order to optimize a classic solution. [V.R. Ghezavati, M.S. Jabal-Ameli, A. Makui (2009)] takes an innovative look response in the supply chain design in reaction to changes in demand which is natural in supply demand network. Company can make more profit if they can respond to changes in demand as quickly and as efficiently as possible. [Anna Nagurney. (2010)] takes a look at design of supply network with minimal total cost. [Arpan Kumar kar. (2010)] takes a look at decision making process implied by manufacturing firms when they are looking at their supplier, the information from this paper is used from the perspective of business process needed for strategic component sourcing. [Mahmut Sonmez (2009)] provides a critique on business process involving supplier selection. The mathematical model is not enough unless used along with innovative business practices and key performance indicator monitoring. The information from this paper will be used to address these questions. [Sandeep Khattar (2006)] provides a case study where sourcing problem was addressed at a large retail company. Finally, [Bowonkim, Jannym.Y.Leung, Kwangtaepark, Guoqinzhang, and Seungchullee] provides a detailed study on the mathematical model in configuring the supplier network for component sourcing. The paper also contains implementation for
iterative solution and algorithm to solve the sourcing problem. This paper is used as a

guide for the implementation.

4 The role of Strategic sourcing in a Supply Chain

Sourcing is the business process used by manufacturers to purchase goods and services.
The manufacturers require components from suppliers which they convert into finished
goods and make profits.

Sourcing process usually includes following steps

- Supplier scoring and assessment
- Supplier selection and contract negotiation
- Design collaboration
- Procurement
- Sourcing planning and analysis

We have been working with our industrial partner ‘Tango Systems Inc.’ to study their
business process used for sourcing components. Following is a description of the company
and the business process used.

5 Tango Systems Inc.

Tango Systems, Inc. was founded in the year 1998 by top business and technical executives
in the Photovoltaic devices (PVD) and thin film engineering fields. It manufactures,
services, markets, and develops tools used in the advanced PVD sputtering systems. It
recognizes the exceptional needs and growth in the economy. These PVD tools are known
for high scale wafer packing and flip chip manufacturing with less cost in owner ship. The
Axcela 200/300 is the name of the tool that was developed by Tango System, Inc. It is
designed to meet the needs of advanced packing and Micro-Electro-Mechanical System (MEMS) industry. Their Small-Batch-Cluster architecture, along with the patent protected D-source magnetron and special ICP cleaning configuration which makes the tool more unique, flexible, and reliable. These capabilities of the tool are enabling Tango Systems Inc to enter more product markets.

The company is located in the heart of Silicon Valley. They have a 1500 square foot facility and a class 100 clean room for process development and prototyping of new range of products. They collaborate with Hionix Inc. which is based in the valley for the process development expertise. Besides, they have an excellent and experienced technical team with wide range of expertise to meet the customer requirements in the thin film industry.

![Figure 3: Axcela 200/300 System](image)

**Figure 3: Axcela 200/300 System**

Source: (Tango Systems 2011)

Tango Systems, Inc has a large customer base which is spread across the globe. Some of them are USA, Taiwan, Singapore, Japan, Korea, Italy and Southern France, Northern France and Germany, UK, Ireland, Scandinavia, and China.
Tango Systems follow a rigorous approach for selecting suppliers for the components needed for their manufacturing. It is the responsibility of the management as detailed in the procedures to control the purchasing process and documentation to ensure that:

- Suppliers are formally assessed to confirm that they can meet the Company’s requirements;
- The requirements for purchased products or services are clearly defined;
- Purchased products or services are inspected or checked.

The flow chart depicting the business process for the production is shown in figure below.
5.1 Tango Systems Axcela Tool

Tango product name is called Axcela. This system can be configured with a combination of both PVD chambers and pre-clean chambers (ICP) depending upon the customer’s requirements. The PVD chambers come with support for 150mm, 200mm and 300mm wafers. Tool capabilities and a snap shot of Axcela system are shown in the figures below.

Figure 5: Production Floor Material Floor Chart

Source: (Tango Systems 2011)
To run the Axcela tool, the tool is integrated with system software which is user friendly, intuitive user interface, and easily understood by the process and equipment engineers. This
software basically includes Maintenance, Flexibility, Date Export capability, control and remote monitoring, semi-s2 compliance. Snapshot of the software is shown below.

![Figure 8: Tool Screen](image-url)

Source: (Tango Systems 2011)

Their tool has an easy accessible design, giving the customer a flexible choice and cost effective design with required applications at low cost of ownership. In the tool each chamber has the capability of running 3 different materials which makes the tool more in demand due to its complexity.

The advantages of this system are -

1. Throughput is high
2. Footprint is small
3. Flexibility in wafer size, process, application.
4. Reliability is high
5. Chambers with high vacuum
6. No remote subsystems
The Axcela has patent protected D-source magnetron that helps in full face erosion and high target sputtering. The contamination level is lower due to the staged vacuum levels from the load lock to the pre clean chamber and last to the PVD chamber. This tool has the flexibility to run 150mm, 200mm and 300mm wafers.

![Wafers](image)

Figure 9: Wafers

Source: (Tango Systems 2011)

The deposition rates on these wafers are controlled by the DC and the RF power in a distributed batch. Tango system has addressed the technical and cost challenges that are in the present market. Axcela’s targeted applications are -

1. Backside Metals (BSM)
2. MEMS
3. TSV(Through silicon Via)
4. Under bump metallization
BSM

This model is mostly used in high performance and different device. In this application the backside metal stack requires strong bond and less stress on the silicon. High stress in the silicon can cause the bonding problems and reliability problems. In this process a clean and oxide free surfaces are difficult to prove and promote the inter atomic bonding so basically the process starts with deposition of adhesion layer which help in promoting the bonding of the underlying semiconductor surfaces.

Axcela systems use for BSM application supports features like

---

**Figure 10: Targeted Applications**

Source: (Tango Systems 2011)
1. With high deposition rates
2. With targets high utilization
3. With good capability in pre clean
4. Minimize the stress on silicon
5. Quick pump down
6. Change target change

Tango design of the tool helps in process advantage, reduce stress and increase the ability of deposition with multiple materials during a single process cycle.

**MEMS**

This is basically used to fabricate physical sensors used in RF communication, microlithography, and bio technology. It is also used to fabricate sensors like accelerometer and gyroscope. Most of these MEMS fabrication process is based on semiconductor fabrication which includes PVD techniques.

Axcela system MEMS application provides

1. High deposition rates.
2. Versatility
3. High target utilization.
Figure 11: MEMS
Source: (Tango Systems 2011)

TSV (Through Silicon Via)

The TSV has emerged as the choice of process for 2-D circuits and interconnecting stacks. The TSV applications include DRAM, flash, power amplifiers, image sensors and FPGA. The Axcela system integrates the ICP etch in the deposition chamber. Its other advantages include

1. High step coverage.
2. Low costs
3. Small foot prints
4. Clean ICP

UBM (under bump metallization)

This process provides a strong stable low electrical resistance connection to the IC’s pads. Materials selection, and deposition process rules the initial tensile within the layers. This
generally needs multi layer deposition of different layers such as adhesion layer and diffusion
layer. Typically the UBM sequence first starts cleaning after the IC pad opening, then the
sputtering on to the wafer and then the second metal sputtering. Basically the resist strip and
etch are used to form pad isolation.

![Figure 12: Under Bump Metallization](image)

Source: (Tango Systems 2011)

### 5.2 Supplier Approval

The majority of Company purchases are made from suppliers with whom the Company
has a record of satisfactory supply or suppliers specifically designated by a Customer. In the
latter case the company can only monitor performance and inform a customer of any failures,
it cannot change such a supplier without the specific agreement of the customer. The record
of approved suppliers takes the form of a Preferred Supplier List that is maintained in the
offices of Production and Engineering, and is maintained for all material purchased for
production and made available to production staff. This list is found on each component
specification for items required for readers & reader systems. All suppliers of materials,
products or services are reviewed to ensure that they can meet the Company’s requirements.
This review includes (as appropriate):
- Past history and performance;
- Evaluation of a trial order, samples or activity;
- Evidence of registration by a recognized authority;
- On site assessment of their capability and quality system;
- Comparative test results with the same or similar products;
- Recommendation or references from other users;
- 100% product verification of all services/products supplied;
- Financial viability.

To ensure all:

1. Documentation used in the purchasing function should be uniform and consistent and that the approved practices should be practiced in the company;
2. Purchase Orders will have all requirements, revisions and Quality provisions;
3. The purchases of material and services are done from approved suppliers;
4. Purchased material meets or exceeds requirements while still being cost and time effective;

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<th>New Vendor Approval Form</th>
<th>Vendor#</th>
</tr>
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<tbody>
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</tbody>
</table>

Terms and Conditions
Step By Step Process followed by Manufacturing

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</tr>
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<tbody>
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Figure 13 : Vendor Approval Form

Source: Tango Systems Inc

5. Where or when required, necessary surveys are issued to the suppliers prior to purchase;
6. Multiple sources for materials/components/services are consistent.

Supplier approval is reviewed at least once per year. This is based on their performance and with the meeting orders placed with them over the previous year.

The results of the review are addressed at Management Review.

Any problems are investigated and where they cannot be resolved, a supplier is no longer used and their name is removed from the Approved Supplier List. If this is not possible due to the lack of alternatives, or a Customer’s specification, a careful check is maintained upon such a supplier and their performance communicated in writing to their senior management and where applicable, the customer who has specified their use.

5.3 Purchasing Data

In all cases, Purchase Orders clearly define the product or service required. They address:

- Product or service required;
- Any relevant standards or regulations that are applicable;
- Delivery requirements;
- Any documentation to be supplied e.g. Certificates of conformity;
- Price and payment details.

A supplier is required to supply to the specification, quantity and price as specified on the Purchase Order. Purchase orders may be faxed, written or telephoned. Where orders are placed by telephone, the order number is quoted and recorded.

5.4 New Suppliers

In the case of no existing approved supplier being available, or where a new one is required, the relevant member of management or nominee decides upon whom to place the
business with. This choice is based on recommendation, delivery, and/or assessment of samples provided.

New suppliers are subject to a trial period that is at the discretion of the originator of the trial. Where a new supplier is being used, any problems are noted and reported to the originator of the trial.

5.5 Production and Service Provision

It is essential that the work carried out by the company be adequately controlled to ensure that it meets the requirements of the customer which is achieved by good planning. The provision of adequate resources properly trained and experienced personnel, clearly defined standards and methods of working, and correct monitoring, and product verification should be planned for. The process is shown in figure 6 below.

![Manufacturing Flow Diagram](image-url)

**Figure 14: Manufacturing Flow**
The scope of this procedure includes:

- Planning of the work process (including validation that it is effective);
- Control of the work process (work instructions);
- Validation of the work;
- Inspection;
- Identification and traceability;
- Control of associated activities including raw materials, handling, packing, storage, preservation and delivery;
- Post delivery activities.

During production outsourced suppliers are requested to inspect the manufacturing process at the stages required. If there are specific requirements identified on the documentation, this is noted and any nonconforming items isolated until the requirements have been met. All items and materials received by the company are held until inspected or otherwise verified as conforming to specifications noted on the purchase order. On satisfactory verification, the products or materials are transferred to inventory and the delivery note is endorsed accordingly. If the product or material does not meet the required specification it is identified and transferred to a Quarantine/Holding Area. Information on such occurrences is passed to Management to resolve the problem.

The inspection status of goods and materials received is indicated by attachment of a suitable label or by immediate placement on shelves or other identified areas. During manufacturing
the status of the product with respect to measuring and monitoring activity throughout product realization is evident and noted on the Traveler.

All data, products and materials delivered to the company carry positive written identification from the supplier, this allows for the back tracing of items.

Where unique identification is required details are recorded on the delivery note upon receipt.

Sources of Traceability and Reference are:

<table>
<thead>
<tr>
<th>Suppliers List</th>
<th>Purchase Orders</th>
<th>Customer Database</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Orders</td>
<td>PO Numbers</td>
<td>Quotations</td>
</tr>
<tr>
<td>Delivery Note</td>
<td>Invoice</td>
<td>Certificate of Conformance</td>
</tr>
<tr>
<td>Drawing No</td>
<td>Project No</td>
<td>Part No</td>
</tr>
</tbody>
</table>

**Figure 15: Sources of traceability of components**

Source: (Tango Systems 2011)

1. Records of materials and their audit trail are maintained on file/computer system.
2. Work in progress is clearly identified at all stages by its documentation.
3. Where traceability is a specified requirement, the requirements are made available when purchasing to ensure that purchased items are traceable.
4. Goods or materials not meeting the specified requirements are dealt with in accordance with Control of Nonconformance.
6 Mathematical Model

6.1 Supply chain management

Manufacturers procure components and raw materials from different suppliers. The raw materials are converted to finished goods and sold to the consumers. Demand for products are usually variable and hence one of the critical decision problem faced by the manufactures is to determine how much of raw material to procure from different suppliers.

To determine the items and amount of materials to be procured, manufacturer should be aware of the market demand for their products. They depend on the results of their market research which usually provides only a statistical distribution of the demand. Based on the forecasted demand, they make purchasing decision while taking into consideration their capacity as well as the capacity of the suppliers.

Since demand forecast gives only a statistical distribution of demand, the manufacturer may produce goods which are actually less or higher than the market demand \( z_k \). Manufacturers would like to avoid such situations as it affects their profit due to lost sales, or stocking costs.

**Mathematical Model**

Following variables were used while describing the supply chain optimization model by Bowonkim, Jannym Y. Leung, Kwangtae Park, Guoqin Zhang, and Seungchul Lee.

\[ k \quad \text{Product Name} \]
\[ y_k \quad \text{Number of units of product k to produce} \]
Table 1: Variables for the nonlinear equation

The supply chain management problem was defined as a nonlinear equation
\[
P = \text{maximize} \sum_{k=1}^{p} \left\{ \int_{0}^{y_k} \left[ r_k z_k - w_k (y_k - z_k) \right] f(z_k) \, dz_k + \int_{y_k}^{\infty} \left[ r_k y_k - u_k (z_k - y_k) \right] f(z_k) \, dz_k \right\}
\]

- \[\sum_{k=1}^{p} d_k y_k - \sum_{i=1}^{n} \sum_{j=1}^{m} c_{ij} x_{ij} - \sum_{k=1}^{p} f_k y_k\]

**Equation 1: Linear Equation for supply chain**

In the above equation, first part is the expected value of revenue when realized demand is less than actual quantity produced \((y_k)\), second part is expected profit when quantity produced is less than the actual demand \((y_k)\), third part is the cost incurred by the manufacturer of the product, fourth part is the raw materials price to the suppliers, and fifth part is the per unit financing cost incurred by the manufacturer.

A set of constraints were defined by the author for the non linear equation. The constraints defined for the objective function were:

- Total raw materials or components required is less than or equal to total that the suppliers can provide.

  \[\sum b_{ik} y_k \leq \sum x_{ij}, \text{ i=1,…,n} \Rightarrow \text{total raw material } b^* y \text{ required is less than or equal to total raw materials from suppliers } j=1\]

**Equation 2: Supply chain constraint 1**

- Total resources required by a supplier to supply the ordered quantity of components is equal to or less than their available capacity.

  \[\sum v_{ij} x_{ij} \leq q_j, \text{ j=1,…, m} \Rightarrow \text{internal resources required by supplier } j \text{ to produce } x \text{ units is less than or equal to the allocated capacity}\, .\]
Equation 3: Supply chain constraint 2

- The original equipment manufacturer has enough capacity to produce the required quantity of finished goods.

\[ \sum t_k y_k \leq Q, \Rightarrow \text{total production is less than the capacity of the vendor.} \]

Equation 4: Supply chain constraint 3

\[ x_{ij} \geq 0, y_k \geq 0 \quad \text{for} \quad i=1,\ldots,n, \quad j=1,\ldots,m, \quad k = 1,\ldots,p \]

The above nonlinear equation with nonlinear constraints was solved by the author using Lagrangean method and Karush-Kuhn-Tucker conditions (Sharma, Sanjay, 2006).

Lagrangean Method and Karush-Kuhn Tucker conditions

Lagrangean method can be used to optimize problems where the objective function is of the following format

Minimize \( f(x_1,x_2,x_3,\ldots,x_n) \)

subject to the constraints \( c_i(x_1,x_2,x_3,\ldots,x_n) = 0, \text{ where } i = 1,\ldots,m \)

Note that the constraints \( c_i \) are set to zero. Lagrange function for \( f(x_1,x_2,\ldots,x_n) \) is shown below

\[
L(x_1,x_2,\ldots,x_n, \lambda_1, \lambda_2, \ldots, \lambda_n) = f(x_1,x_2,x_3,\ldots,x_n) + \sum_{i=1}^{m} \lambda_i c_i(x_1,x_2,\ldots,x_n) \quad \text{--------(6)}
\]

where \( \lambda_i \) are the Lagrange multipliers.

Optimal values are calculated after differentiating the Lagrange function above with each variable and equating them to zero as shown below.

\[
\frac{\partial L}{\partial x_1} = 0, \quad \frac{\partial L}{\partial x_2} = 0,\ldots, \quad \frac{\partial L}{\partial x_n} = 0, \text{ and } \quad \text{-------------------------------------(7)}
\]
\[ \frac{\partial L}{\partial \lambda_1} = 0, \frac{\partial L}{\partial \lambda_2} = 0, \ldots, \frac{\partial L}{\partial \lambda_m} = 0 \]  \hspace{1cm} (8)

Karush-Kuhn Tucker conditions are used when the constraints for the objective function are non-zero like the function

Minimize \( f(x_1, x_2, x_3, \ldots, x_n) \)  \hspace{1cm} (9)

subject to the constraints \( c_i(x_1, x_2, x_3, \ldots, x_n) \leq 0 \), where \( i = 1, \ldots, m \)  \hspace{1cm} (10)

In such scenarios slack variables \( S_i \) are used to equate the constraints to zero as shown below.

\[ c_i(x_1, x_2, x_3, \ldots, x_n) + S_i^2 = 0 \text{ where } i = 1, 2, \ldots, m \]  \hspace{1cm} (11)

Then the equation is solved as a Lagrangean.

Lagrange for \( f(x_1, x_2, x_3, \ldots, x_n) \) is

\[ L(x_1, x_2, \ldots, x_n, \lambda_1, \lambda_2, \ldots, \lambda_m, S_1, S_2, \ldots, S_m) = \]  \hspace{1cm} (12)

\[ f(x_1, x_2, x_3, \ldots, x_n) + \sum_{i=1}^{m} \lambda_i [c_i(x_1, x_2, \ldots, x_n) + S_i^2] \]

\( \lambda_i \) are the Lagrange multipliers.

The Karush-Kuhn Tucker conditions for solving the function are defined as

\[ \frac{\partial f}{\partial x_j} + \sum \lambda_i \frac{\partial c_i}{\partial x_j} = 0, \text{ where } j = 1, 2, \ldots, n \]  \hspace{1cm} (13)

\[ \lambda_i c_i = 0, \text{ where } i = 1, 2, \ldots, m \]  \hspace{1cm} (14)

\[ c_i \leq 0, \text{ where } i = 1, 2, \ldots, m \]  \hspace{1cm} (15)

\[ \lambda_i \geq 0, \text{ where } i = 1, 2, \ldots, m \]  \hspace{1cm} (16)

**Solution to the nonlinear objective function for supply chain**

The paper (Reference) used Karush-Kuhn-Tucker (KKT) conditions for solving
the non-linear equation (1) with specified constraints.

The Lagrangian for the non-linear equation will be

\[
L = \sum_{k=1}^{P} \left\{ \int_{0}^{y_k} \left[ r_k z_k - w_k(y_k - z_k) \right] f(z_k) dz_k + \int_{0}^{\infty} \left[ r_k y_k - u_k(z_k - y_k) \right] f(z_k) dz_k \right\} \sum_{k=1}^{p} y_k - \sum_{i=1}^{n} \sum_{j=1}^{m} c_{ij} x_{ij} \right\}
\]  

\[+ \sum_{i=1}^{n} \sum_{j=1}^{m} \sum_{k=1}^{p} \lambda_i \left( \sum_{j=1}^{m} b_{ik} y_k \right) + \sum_{i=1}^{n} \sum_{j=1}^{m} \mu_j \left( \sum_{i=1}^{n} v_{ij} x_{ij} \right) + \eta \left( Q - \sum_{k=1}^{p} y_k \right) \]  

\[\text{--------------------------(17)}\]

where

\[\lambda_i = \text{Lagrange multiplier for raw material } i\]

\[\mu_j = \text{Lagrange multiplier for supplier } j\]

\[\eta = \text{Lagrange multiplier for supplier capacity}\]

KKT first order optimality conditions for the Lagrangian equation will be

\[\frac{\partial L}{\partial y_k} \leq 0 , y_k \geq 0 \]  

\[\text{-------------------------------------------(18)}\]

\[\frac{\partial L}{\partial x_{ij}} \leq 0 , x_{ij} \geq 0 \]  

\[\text{-------------------------------------------(19)}\]

\[\frac{\partial L}{\partial \lambda_i} \geq 0 , \lambda_i \geq 0 \]  

\[\text{-------------------------------------------(20)}\]

\[\frac{\partial L}{\partial \mu_j} \geq 0 , \mu_j \geq 0 \]  

\[\text{-------------------------------------------(21)}\]

\[\frac{\partial L}{\partial \eta} \geq 0 , \eta \geq 0 \]  

\[\text{-------------------------------------------(22)}\]

Differentiating L with respect to the number of units to be produced \(y_k\)

\[\frac{\partial L}{\partial y_k} = 0 - w_k F(y_k) + r_k \ast 1 - u_k \ast 0 - u_k \ast (-1) \ast (r_k \ast F(y_k) - u_k \ast F(y_k)) - d_k \ast 1 \ast 0 + \sum_{i}^{\lambda_i \ast (0 - b_{ik})} + \mu_j \ast (0 - 0) + \eta(0 - t_k \ast 1)\]

therefore
\[ \frac{\partial L}{\partial y_k} = -w_k F(y_k) + r_k + u_k - (r_k - u_k) F(y_k) - d_k - \sum_{i} \lambda_i b_{ik} - \eta t_k \leq 0 \text{ and } y_k \geq 0 \quad (24) \]

\[ [r_k + u_k - d_k - \sum_{i} \lambda_i b_{ik} - \eta t_k} - (w_k + r_k + u_k) F(y_k)] y_k = 0 \quad \text{------------------------(25)} \]

Differentiating \( L \) with respect to amount of raw material \( i \) from supplier \( j \) (\( x_{ij} \))

\[ \frac{\partial L}{\partial x_{ij}} = 0 + 0 - c_{ij} + \lambda_i (1 - 0) + \mu_j (0 - v_{ij}) + \eta (0 - 0) \]

therefore

\[ \frac{\partial L}{\partial x_{ij}} = -c_{ij} + \lambda_i - \mu_j v_{ij} \leq 0 \text{ and } x_{ij} \geq 0 \quad \text{-----------------------------(27)} \]

\[ (-c_{ij} + \lambda_i - \mu_j v_{ij}) x_{ij} = 0 \quad \text{-----------------------------------(28)} \]

Differentiating \( L \) with respect to the Lagrange multiplier for raw material \( i \)

\[ \frac{\partial L}{\partial \lambda_i} = 0 + 0 - 0 + \sum_{i} x_{ij} - \sum_{i} b_{ik} y_k + 0 + 0 \leq 0 \text{ and } \lambda_i \geq 0 \]

therefore

\[ \frac{\partial L}{\partial \lambda_i} = \sum_{i} x_{ij} - \sum_{i} b_{ik} y_k \leq 0 \text{ and } \lambda_i \geq 0 \quad \text{-------------------------(30)} \]

\[ (\sum_{i} x_{ij} - \sum_{i} b_{ik} y_k) \lambda_i = 0 \quad \text{----------------------------------(31)} \]

Differentiating \( L \) with respect to the Lagrange multiplier for supplier \( j \)

\[ \frac{\partial L}{\partial \mu_j} = 0 + 0 - 0 + (q_j - \sum v_{ij} x_{ij}) + 0 \leq 0 \text{ and } \mu_j \geq 0 \]

therefore

\[ \frac{\partial L}{\partial \mu_j} = q_j + \sum v_{ij} x_{ij} \leq 0 \text{ and } \mu_j \geq 0 \quad \text{-------------------------(33)} \]

\[ (q_j + \sum v_{ij} x_{ij}) \mu_j = 0 \quad \text{-----------------------------------------(34)} \]
Differentiating L with respect to the Lagrange multiplier for manufacturers capacity Q

\[ \frac{\partial L}{\partial \eta} = 0 + 0 - 0 + 0 + 0 + Q - \sum_{k=1}^{p} t_k y_k \leq 0 \text{ and } \eta \geq 0 \]

therefore

\[ \frac{\partial L}{\partial \eta} = Q - \sum_{k=1}^{p} t_k y_k \leq 0 \text{ and } \eta \geq 0 \] \hspace{1cm} \text{(36)}

\[ (Q - \sum_{k=1}^{p} t_k y_k) = 0 \] \hspace{1cm} \text{(37)}

Optimal solution for the equation satisfies the above first order conditions from 24 to 37.

An iterative solution method was followed in solving the objective function.

6.2 Iterative solution

We first consider the case when the resource capacity constraint for the manufacturer is not tight; in this case, \( \eta = 0 \). The iterative solution procedure is as follows: first, using some values for \( \lambda \) (initially zero), we obtain the values of the \( y_k \)'s according to (14a). Using these \( y_k \) values, we solve the linear program \( P_2(y) \). Next, we update the values of \( \lambda \) according to the optimal dual variables, and re-compute the \( y_k \)'s according to (14a). We then iterate back and forth between solving the linear program \( P_2(y) \) and computing \( y \) according to (14a) until the values of \( y, x, \) and \( \lambda \) converge. In the implementation, some care has to be taken in the initialization of the variables, the ‘‘step-size’’ in the updating of \( y \), and the convergence criteria.
6.3 Implementation

The iterative algorithm is implemented as an Excel macro. The excel sheet consists of input sheet for input parameters and controls for running the algorithm. Based on the user input for the product demand and statistical quantities the optimization routine can be called by using the user interface button.

Following is the screen shot for the user input section

<table>
<thead>
<tr>
<th>Product Information</th>
<th>Input Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>Demand</td>
</tr>
<tr>
<td>P1</td>
<td>12</td>
</tr>
<tr>
<td>P2</td>
<td>50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product Component Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
</tr>
<tr>
<td>P1</td>
</tr>
<tr>
<td>P2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supplier Cost for Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
</tr>
<tr>
<td>IS</td>
</tr>
<tr>
<td>LG</td>
</tr>
<tr>
<td>samsung</td>
</tr>
</tbody>
</table>

Figure 26: Screenshot for the data input screen

The first section is for product information. For the algorithm implementation we need the demand, price, resource usage, mean demand, variation of the demand, under stocking and overstocking cost.

The bottom section is for the product component distribution derived from bill of material.

The last section is for the supplier cost for the component.

The algorithm can be executed using the section shown below
Then click on the begin calculation button will run the algorithm, till optimal solution is reached as shown in the graphic below:

This means that the algorithm has found the optimal solution and the results can be seen in the results section with overall cost for the OEM.

The algorithm is implemented as follows

'get the number of suppliers
Dim supplierCount As Integer

'initialize supplier count to 8
supplierCount = 8

'set all lamda[i]= 0
Dim supplier1 As Double
supplier1 = 12

Dim supplier2 As Double
supplier2 = 12

Dim supplier3 As Double
supplier3 = 12

Dim supplier4 As Double
supplier4 = 12

Dim supplier5 As Double
supplier5 = 12

Dim supplier6 As Double
supplier6 = 12

Dim supplier7 As Double
supplier7 = 12

Dim supplier8 As Double
supplier8 = 12

Dim sumSupp1 As Double
Dim sumSupp2 As Double
Dim sumSupp3 As Double
Dim sumSupp4 As Double
Dim sumSupp5 As Double
Dim sumSupp6 As Double
Dim sumSupp7 As Double
Dim sumSupp8 As Double

Sheets("product bill of materials").Select
Range("C12").Value = supplier1
Range("D12").Value = supplier2
Range("E12").Value = supplier3
Range("F12").Value = supplier4
Range("G12").Value = supplier5
Range("H12").Value = supplier6
Range("I12").Value = supplier7
Range("J12").Value = supplier8

Dim iterationCounter As Integer
Dim stepSize As Double
Dim previousRk As Double

previousRk = -99999.9999

'initialize stepSize = 0
stepSize = 1

iterationCounter = 0

Do While True

'call solver for p2(y)
Sheets("Supplier Cost cij").Select
SolverReset
SolverOk SetCell:="$C$21", MaxMinVal:=2, ValueOf:="0", ByChange:="$O$4:$V$6"
SolverAdd CellRef:="$C$23", Relation:=1, FormulaText:="$E$23"
SolverAdd CellRef:="$O$4:$V$6", Relation:=3, FormulaText:="0"
SolverAdd CellRef:="$O$7:$V$7", Relation:=1, FormulaText:="$O$13:$V$13"
SolverAdd CellRef:="$P$31:$P$33", Relation:=1, FormulaText:="$O$31:$O$33"
SolverSolve True
Sheets("product bill of materials").Select
'MsgBox "Inner"
SolverReset
SolverOk SetCell:="$B$16", MaxMinVal:=1, ValueOf:="0", ByChange:="$C$12:$J$12"
SolverAdd CellRef:="$B$16", Relation:=3, FormulaText:="0"
SolverAdd CellRef:="$C$12:$J$12", Relation:=3, FormulaText:="0"
SolverDelete CellRef:="$C$12:$J$12", Relation:=1, FormulaText:="99"
SolverSolve True
Sheets("Supplier Cost cij").Select
Dim newRkValue As Double
newRkValue = Range("T16").Value
If newRkValue > previousRk And previousRk <> -99999.9999 Then
    Range("C34").Value = iterationCounter
Sheets("Decision Problem").Select

MsgBox "Optimal solution"

Exit Do

End If

'break condition is problem is not calculated

iterationCounter = iterationCounter + 1

previousRk = newRkValue

supplier1 = Range("B9").Value

supplier2 = Range("C9").Value

supplier3 = Range("D9").Value

supplier4 = Range("E9").Value

supplier5 = Range("F9").Value

supplier6 = Range("G9").Value

supplier7 = Range("H9").Value

supplier8 = Range("I9").Value

sumSupp1 = sumSupp1 + supplier1

sumSupp2 = sumSupp2 + supplier2

sumSupp3 = sumSupp3 + supplier3

sumSupp4 = sumSupp4 + supplier4

sumSupp5 = sumSupp5 + supplier5

sumSupp6 = sumSupp6 + supplier6

sumSupp7 = sumSupp7 + supplier7

sumSupp8 = sumSupp8 + supplier8
'change the step size here
Sheets("product bill of materials").Select
stepSize = stepSize / 2
Range("C12").Value = (supplier1 + stepSize * ((sumSupp1 / iterationCounter) - supplier1)) * 100
'MsgBox (supplier1 + stepSize * ((sumSupp1 / iterationCounter) - supplier1)) * 100
Range("D12").Value = (supplier2 + stepSize * ((sumSupp2 / iterationCounter) - supplier2)) * 100
Range("E12").Value = (supplier3 + stepSize * ((sumSupp3 / iterationCounter) - supplier3)) * 100
Range("F12").Value = (supplier4 + stepSize * ((sumSupp4 / iterationCounter) - supplier4)) * 100
Range("G12").Value = (supplier5 + stepSize * ((sumSupp5 / iterationCounter) - supplier5)) * 100
Range("H12").Value = (supplier6 + stepSize * ((sumSupp6 / iterationCounter) - supplier6)) * 100
Range("I12").Value = (supplier7 + stepSize * ((sumSupp7 / iterationCounter) - supplier7)) * 100
Range("J12").Value = (supplier8 + stepSize * ((sumSupp8 / iterationCounter) - supplier8)) * 100
If iterationCounter > 100 Then
    MsgBox "Limit Exit"
    Exit Do
End If

Loop

Sheets("Decision Problem").Select

6.4 Solution Behavior in Different Demand scenarios

In order to test the implementation under different conditions we have run the implementation under different demand conditions. This has given us important information for fine tuning the algorithm. Out of many sample runs of the algorithm following are the two conditions.

1. The condition when the cost of the component is same but the variability, and average demand are different. This input condition is shown in the figure below

<table>
<thead>
<tr>
<th>Product Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>P1</td>
</tr>
<tr>
<td>P2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product Component Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>P1</td>
</tr>
<tr>
<td>P2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supplier Cost for Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>IS</td>
</tr>
<tr>
<td>LG</td>
</tr>
<tr>
<td>samsung</td>
</tr>
</tbody>
</table>

After running the implementation for optimal solution we arrive at the condition where the result are distributed taking into account is component disparity among the product.
2. The second case is when the cost is the same and product component distribution is also the similar. This condition is shown in the figure below.

<table>
<thead>
<tr>
<th>Product Information</th>
<th>Demand</th>
<th>price</th>
<th>resource usage</th>
<th>mean demand in no of units</th>
<th>std. deviation of demand</th>
<th>understocking cost</th>
<th>overstocking cost</th>
<th>direct production cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td>12</td>
<td>100</td>
<td>10</td>
<td>50</td>
<td>34</td>
<td>90</td>
<td>1000</td>
<td>67</td>
</tr>
<tr>
<td>P2</td>
<td>50</td>
<td>137</td>
<td>10</td>
<td>50</td>
<td>70</td>
<td>2</td>
<td>1000</td>
<td>34</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Product Component Distribution</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>15</td>
<td>11</td>
<td>10</td>
<td>56</td>
</tr>
<tr>
<td>P2</td>
<td>34</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>20</td>
<td>11</td>
<td>11</td>
<td>23</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Supplier Cost for Component</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>LG</td>
<td>11</td>
<td>11</td>
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<td>11</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>samsung</td>
<td>11</td>
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<td>11</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>11</td>
</tr>
</tbody>
</table>

After running the implementation we see this time the solution as taken into consideration the product component distribution and based on the demand and variability has assigned equal amount to all suppliers. This is seen in the figure below:

<table>
<thead>
<tr>
<th>Decision Problem</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>IS</td>
<td>47</td>
</tr>
<tr>
<td>LG</td>
<td>41</td>
</tr>
<tr>
<td>samsung</td>
<td>32</td>
</tr>
</tbody>
</table>

Total Cost 4531
## Decision Problem

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS</td>
<td>15</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>12</td>
<td>7</td>
<td>7</td>
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<td>LG</td>
<td>15</td>
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<td>7</td>
<td>12</td>
<td>7</td>
<td>7</td>
<td>26</td>
</tr>
<tr>
<td>samsung</td>
<td>15</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>12</td>
<td>7</td>
<td>7</td>
<td>26</td>
</tr>
</tbody>
</table>

Total Cost: 2904
7 Economic Justification

7.1 Executive Summary

Original Equipment Manufacturers (OEMs) are lean manufacturing enterprises that pursue excellence in manufacturing and profitability. With the globalization of supply chain, raw materials and components are sourced from suppliers around the world. Hence achieving manufacturing excellence depends on identifying and working with high quality suppliers. Relying on a globally distributed chain of component suppliers has made the supply chain management a very complex task. Wastage of resources due to improper management of supply the chain is quite common in manufacturing industry.

There is a strong argument for the management to focus on reducing wastages and thus costs in supply chain as reduction in internal costs contributes directly to the bottom line of the company. Table below shows a hypothetical scenario on how savings in supply chain can directly add to the bottom line of a company. Even if whole direct costs are considered as capital expenditures and indirect costs as expenses, a five percent reduction in indirect costs with increase the net income after taxes by 15 percent.

<table>
<thead>
<tr>
<th>Spending Type</th>
<th>Initial Spending</th>
<th>Percentage Cost Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>5%</td>
</tr>
<tr>
<td>Direct Costs</td>
<td>$300</td>
<td>$15</td>
</tr>
<tr>
<td>Indirect Costs</td>
<td>$150</td>
<td>$7.5</td>
</tr>
<tr>
<td>Income</td>
<td></td>
<td>$1000</td>
</tr>
<tr>
<td>Revenue</td>
<td>$1000</td>
<td>$1000</td>
</tr>
<tr>
<td>Income</td>
<td>$50</td>
<td>$57.5</td>
</tr>
<tr>
<td>------------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Net Income</td>
<td>$35</td>
<td>$40.25</td>
</tr>
<tr>
<td>(tax rate 30%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage</td>
<td>15%</td>
<td>30%</td>
</tr>
<tr>
<td>Improvement</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

While optimizing the supply chain, proper business process should be followed to avoid any intermediate costs that can nullify the benefits. We believe that most of the small and medium scale businesses will not have sufficient expertise on business process and hence there is an opportunity to provide consultancy services on optimization of component sourcing and business processes.

Our solution which is more economical when compared to solutions from competition without compromising on benefits has a strong potential to succeed in the market. Our software and savings can achieve a minimum savings of 5% over total sourcing costs. Our price point will be $60,000 for the software which includes free consultancy services for one quarter and $20,000 per quarter for consultancy services. This implies a company with $5 million in sourcing budget can achieve a minimum yearly net savings of $110,000.

The price point for our package and services compares well with the average initial investment requirement of $500,000 dollars and consultancy service charges of $100,000 to $200,000 for packages and services from our competition. The solution will be sold as a combination of software and services. While software will be the tool to gain customers, it will be the services that will be main revenue stream of the company and make it profitable.
7.2 Problem Statement

Original Equipment Manufacturers (OEM’s) are lean manufacturing enterprises than pursue excellence in manufacturing and profitability. With the globalization of supply chain where the raw materials are sourced from suppliers around the world - achieving manufacturing excellence depends on developing high quality suppliers while achieving excellence in profitability depends on cost effectiveness of the supply chain as well.

It is quite likely that OEM’s have identified more then one supplier for each component who can meet the quality requirements. Choice of quality suppliers gives OEMs more opportunities to reduce their unit costs. Some of the opportunities have potential to introduce unforeseen costs that can increase the supply chain costs and thus defeat the purpose (Industry Week, 2008). Thus manufacturers have to employ appropriate sourcing strategies for their raw materials, components, and semi-finished goods. This not only involves careful selection of suppliers, but also cultivating relationships with their suppliers to form strategic partnerships (Industry Week, 2008). If the operations department does not make sourcing decisions methodically, many issues can arise - including higher costs, insufficient inventory for critical components, and lower customer satisfaction. The end result will be reduced profit margins and sales for the organization.

The report on competitiveness of European Aerospace industry (Europa, 2011) refers to these sourcing trends in detail. According to the report the industry is transitioning from a supply chain that focuses on cost reduction alone to a more complex and cooperative supply chain whereby more and more responsibilities and risks are transferred to the suppliers. The suppliers are expected to be further internationalized to take advantage of international diversity and expertise. These changes are driven by various factors like pressure from
customers to reduce costs and need to maintain technology leadership over new competitors. The changes are shown in figure below. As shown in the figure, OEM’s focus will be only on the final product integration with the responsibility of integration and quality of components, sub-systems and systems being moved to their suppliers.

![Figure 16: Changes in the structure of the supply chain](image)


**Figure 16: Changes in the structure of the supply chain**

The transition to the above structure is changing the supply chain model from a traditional linear model to an unstructured network like model as shown in figure below thus making supply chain management tasks even more complex.
Figure 17: Network like model of supply chain

To explain how difficult it is to improve profit through increasing sales alone, consider the bar graph in figure below. It describes the expenses and profit as percentage of total revenue for different industry verticals. The tallest bar shows the total revenue, which is given as 100 percent for all industry verticals. The light blue colored bar shows the total spending as a percentage of total revenue. From the graph we can see that semiconductor industry spends 58% of its total revenue. The shortest bar graphs show the net profit margin across different industry verticals. From the bar graph we can see that the net profit margin for the semiconductor industry is 9.9%. Besides, the table in the picture shows the revenue increase needed to improve the bottom line by 1% for various industry verticals. From the table we can see that for the semiconductor industry, the revenues have to go up by over 10 percent for the bottom line to go up by one percent. For some other industries like Aerospace and defense, Chemicals, and Computers the revenues has to go up by 20 percent or higher for
the profit to go by a percentage point. Hence it is clear that trying to increase profit through increasing sales alone will not be the most practical way.

Figure 18: Spending and net profit as % of revenue


The income statement below shows the financial impact on the bottom line of a hypothetical organization with annual revenue of $250 million dollars if best in class strategic sourcing is employed. In the income statement, “Industry Norm Performer” refers to the typical scenario in the industry whereby only 35% of spending goes through strategic sourcing and a cost reduction of only 7.5% are achieved. “Best-in-class Performer” refers to
the scenario where strategic sourcing is applied to 82% of the total spending and an average cost reduction of 14.4% is attained. In the statement, “Annual sourcing savings” refers to the savings possible if strategic sourcing is strictly implemented while the “Annual implemented savings” refers to actual savings achieved through implementing the recommendations for only 75% of possible cases. Implementing the recommendations for only about 75% of the possible cases can be due to variety of factors like customer requirements for a specific vendor, and other business considerations. Further we can see that by transforming from a standard industry performer to best-in-class performer, the company can improve the bottom line by 6% without any increase in sales.

### Table 6: Strategic Sourcing Impact on Costs, Income, and Market Value

<table>
<thead>
<tr>
<th></th>
<th>Industry Norm Performer</th>
<th>Best-in-Class Performer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenues</td>
<td>$250,000,000</td>
<td>$250,000,000</td>
</tr>
<tr>
<td>Starting Spend Position</td>
<td>$125,000,000</td>
<td>$125,000,000</td>
</tr>
<tr>
<td>Spend strategically sourced</td>
<td>$43,750,000</td>
<td>$102,500,000</td>
</tr>
<tr>
<td>Annual sourcing savings</td>
<td>$3,281,250</td>
<td>$14,760,000</td>
</tr>
<tr>
<td>Annual implemented savings</td>
<td>$2,460,938</td>
<td>$11,070,000</td>
</tr>
<tr>
<td><strong>Implemented Cost Savings Delta</strong></td>
<td><strong>$8,609,062,500</strong></td>
<td></td>
</tr>
<tr>
<td>Operating Income</td>
<td>$127,460,938</td>
<td>$136,070,000</td>
</tr>
<tr>
<td>Interest and Other Income</td>
<td>$13,000,000</td>
<td>$13,000,000</td>
</tr>
<tr>
<td>Taxes (@ 38%)</td>
<td>($48,435,156)</td>
<td>($51,706,600)</td>
</tr>
<tr>
<td>Net Income</td>
<td>$92,025,781</td>
<td>$97,363,400</td>
</tr>
<tr>
<td>Net Shares Outstanding (M)</td>
<td>15,000,000</td>
<td>15,000,000</td>
</tr>
<tr>
<td>Earnings Per Share</td>
<td>$6.14</td>
<td>$6.49</td>
</tr>
<tr>
<td>P/E Ratio</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Market Value per Share</td>
<td>$61.35</td>
<td>$64.91</td>
</tr>
<tr>
<td><strong>Improvement</strong></td>
<td>6%</td>
<td></td>
</tr>
</tbody>
</table>

Source: Aberdeen Group, December 2005

Figure 19: Strategic sourcing impact on Costs, Income, and Market Value
Current solutions available are very expensive. A typical business process sourcing contract involves an initial outlay of $500,000 or more and consultancy services of $100,000 to $200,000 or more (T+D, 2007) which makes it very expensive for many small and mid-scale enterprises. Hence there is a market for a more economical solution that can help customers save money through optimizing the supply chain without compromising on actual achievable savings.

7.3 Solution and Value Proposition

We intend to develop an optimized sourcing model for the Original Equipment Manufacturers which will help the OEMs to be the best in class. The sourcing model, which is an implementation of a mathematical research journal, will provide OEM’s with appropriate sourcing strategy that should be employed to maximize the profit. The model will be vertical independent i.e. with minor modifications the model can be applied across different manufacturing verticals including non hi-tech industries. Thus we will be able to offer the solution at a much lower price point. The GUI front end that we have developed will mask the complexities of the algorithm and hence making it easy to use for the customers. Consultancy services will be provided to the customers to fine tune the algorithm depending on the individual needs of the customer. The solution will be priced cheaper than the competition while providing same level of benefits. The model will be tested using market research data and case studies will be presented as part of the report to justify the optimization goals and results.
7.4 Market Size

Original equipment manufacturers - large or small – that source components for conversion to finished goods are potential customers. As described in the problem statement, manufacturing in different verticals such as hi-tech, semiconductors, retail consumer goods, and aerospace spends significant portion of their sales revenue for sourcing. Since our optimization technology is not vertical dependent, we intend to target these market segments for our project.

The addressable market size for each segment is not only related to the demand but also is function of number of business to business transaction for components. In the case of semiconductor industry the demand for semi-conductor manufacturing equipment demand for year 2010 was over $60 billion dollars as shown in figure below (semi, 2011).

**Worldwide Semiconductor Revenues**

*Year-to-Year Percent Change*

![Graph](image)

*Source: WSTS*

**Figure 20: Worldwide semiconductor revenues**
If we consider another industry vertical of aerospace, the sales for year 2009 was more than $200 billion dollars as shown in figure below.

Figure 21: Aerospace Industry Sales

Besides, to have a perspective on how sourcing is going to evolve in future, following figure (figure 15) illustrates how the procurement of components, sub-systems, and systems will be for European aircraft industry in year 2020. The expected global sourcing outside Europe is expected to be over 40 percent of value from current values of less than 25%. Hence, sourcing optimization has tremendous growth potential as well.
In the case of number of transactions, according to ARIBA - a leading business to business service provider – more than 23 million purchase orders and 11.5 million invoices were processed by ARIBA network alone (Source: ARIBA).

7.5 Competitors

There are several vendors providing supply chain optimization services. Main competitors are listed below.

7.5.1 JDA

JDA software delivers best in class supply chain software solutions that help businesses increase revenue, profits, and operate in a more efficient and sustainable way (JDA, 2011). The company has been in existence for over 25 years and has served more than 6000 customers. The company is mainly focused on large customers with the average selling price of their software being $786,000 for the trailing 12 months ending in September 2011 (JDA,
2011). This makes their software and services out of reach for many of the small and medium
scale businesses.

7.5.2 ARIBA

ARIBA is a leading provider of collaborative business commerce solutions (ARIBA, 2011).
According to the company - 94 out of 100 fortune 100 companies, 80 percent of fortune 500
companies, and 500,000 other companies use their solutions to buy and sell more than $450
million worth of goods and services per day through over 100,000 transactions saving $60
million. In addition their solutions have helped companies find new business opportunities,
and secure financing. Their focus is on their sourcing network whereby the customers are
encouraged to use their network to realize maximum savings, while we work our customers
existing sourcing network to realize maximum savings.

7.5.3 MANHATTAN ASSOCIATES

Manhattan Associates help companies streamline their supply chains to achieve lower costs,
higher profits, and happier customers (MANHATTAN, 2011). They have over 1200
customers. Their supply chain solution is called SCOPE which according to the company –
provides complete supply chain awareness. Their focus is on their sourcing network whereby
the customers are encouraged to use their network to realize maximum savings, while we
work our customers existing sourcing network to realize maximum savings.

7.6 Potential Customers

Any manufacturing organization - large or small - which makes component sourcing
decisions regularly in order to better react efficiently to the variation in demand are potential
customers for the company. As the optimization technology is independent of industry
verticals, potential customers can be in different industries like semiconductor equipment, aerospace, and computers. In order for the company to benefit from software and services, we will target only customers who have a minimum supply chain budget of $5 million dollars. This is based on the price point for our software and services, and the savings we expect our customers to realize.

We expect our software and services can achieve a minimum savings of 5% over total sourcing costs. Our price point will be $60,000 for the software which includes free consultancy services for one quarter and $20,000 per quarter for consultancy services. Hence a company with $5 million in sourcing budget can achieve a minimum yearly net savings of $5 million * 0.05 - $140,000 = $110,000

To name a few, our potential customers in Silicon Valley include Intel Corporation, Cisco Systems, Advanced Micro Devices, and Applied Materials. All these companies have vast supply chain network with components sourced from around the world.

7.7 Cost Analysis of the Company

Since we will be providing software packages and consultancy services, the costs are mainly for software development, and maintenance, office, and for people to provide necessary services. Based on our forecast, as a startup organization we will need some initial “Investment Capital” of about $1,200,000 before breaking even. Out of $1.2 million dollars, as an initial investment $500,000 will be needed to start and equip the company with necessary resources like office space, office equipment, people, computers, software model development costs, and initial marketing costs required to get the first few customers. Rest $700,000 will be needed over the next three quarters to finance the expected deficit in our cash flow. Our target is to breakeven at the end of first year of operation. We plan to tap the
venture capital community in Silicon Valley for money. The funding is expected to cover
the initial setup, model development costs, and initial marketing costs required to get the first
few customers until the company attains positive cash flow. The costs will have both fixed
and variable components.

The fixed cost includes wages; software costs, leasing costs and other utility costs. The
estimates for the fixed costs are shown in the table (Table 1) below.

<table>
<thead>
<tr>
<th></th>
<th>Q2 11-Q1 12</th>
<th>Q2 12-Q1 13</th>
<th>Q2 13-Q1 14</th>
<th>Q2 14-Q1 15</th>
<th>Q2 15-Q1 16</th>
<th>Q2 16-Q1 17</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software</td>
<td>49,000</td>
<td>12,000</td>
<td>12,000</td>
<td>12,000</td>
<td>12,000</td>
<td>12,000</td>
</tr>
<tr>
<td>Office equipment</td>
<td>26,000</td>
<td>8,000</td>
<td>8,000</td>
<td>8,000</td>
<td>8,000</td>
<td>8,000</td>
</tr>
<tr>
<td>Leasing Office Space</td>
<td>80,000</td>
<td>80,000</td>
<td>80,000</td>
<td>80,000</td>
<td>80,000</td>
<td>80,000</td>
</tr>
<tr>
<td>Furniture</td>
<td>10,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Utilities</td>
<td>12,000</td>
<td>12,000</td>
<td>12,000</td>
<td>12,000</td>
<td>12,000</td>
<td>12,000</td>
</tr>
<tr>
<td>Telephone and Internet</td>
<td>8,000</td>
<td>8,000</td>
<td>8,000</td>
<td>8,000</td>
<td>8,000</td>
<td>8,000</td>
</tr>
<tr>
<td>Total Fixed Costs</td>
<td>185,000</td>
<td>120,000</td>
<td>120,000</td>
<td>120,000</td>
<td>120,000</td>
<td>120,000</td>
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<tr>
<td>Wages</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CEO</td>
<td>200,000</td>
<td>200,000</td>
<td>200,000</td>
<td>200,000</td>
<td>200,000</td>
<td>200,000</td>
</tr>
<tr>
<td>VP Engineering</td>
<td>160,000</td>
<td>160,000</td>
<td>160,000</td>
<td>160,000</td>
<td>160,000</td>
<td>160,000</td>
</tr>
<tr>
<td>VP Marketing</td>
<td>160,000</td>
<td>160,000</td>
<td>160,000</td>
<td>160,000</td>
<td>160,000</td>
<td>160,000</td>
</tr>
<tr>
<td>Sales and Marketing</td>
<td>120,000</td>
<td>120,000</td>
<td>120,000</td>
<td>120,000</td>
<td>120,000</td>
<td>120,000</td>
</tr>
<tr>
<td>Product Development Engineers (2)</td>
<td>200,000</td>
<td>200,000</td>
<td>200,000</td>
<td>200,000</td>
<td>200,000</td>
<td>200,000</td>
</tr>
<tr>
<td>Quality Assurance</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>HR</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
</tr>
<tr>
<td>Accounting</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
</tr>
<tr>
<td>Administrative</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
</tr>
<tr>
<td>Employee Benefits</td>
<td>360,000</td>
<td>360,000</td>
<td>360,000</td>
<td>360,000</td>
<td>360,000</td>
<td>360,000</td>
</tr>
<tr>
<td>Customers</td>
<td>11</td>
<td>35</td>
<td>59</td>
<td>83</td>
<td>107</td>
<td>130</td>
</tr>
<tr>
<td>Consultant Engineer, one for 10 customers</td>
<td>100,000</td>
<td>240,000</td>
<td>440,000</td>
<td>640,000</td>
<td>780,000</td>
<td>920,000</td>
</tr>
<tr>
<td>Benefits</td>
<td>50,000</td>
<td>120,000</td>
<td>220,000</td>
<td>320,000</td>
<td>430,000</td>
<td>480,000</td>
</tr>
<tr>
<td>Total Wages</td>
<td>1,710,000</td>
<td>1,920,000</td>
<td>2,220,000</td>
<td>2,520,000</td>
<td>2,770,000</td>
<td>2,960,000</td>
</tr>
<tr>
<td>Total Fixed Expenses</td>
<td>1,895,000</td>
<td>2,040,000</td>
<td>2,340,000</td>
<td>2,640,000</td>
<td>2,890,000</td>
<td>3,080,000</td>
</tr>
</tbody>
</table>

Table 2: Projected Fixed Costs for the company

The breakdown of the fixed costs into wages and other costs like office space and other infrastructure is shown in the figure below.
Figure 23: Projected Fixed Costs per year

We estimate the variable cost to be mainly driven by the marketing, sales, and consultancy services provided. Our estimates for the variable cost component are shown below.

<table>
<thead>
<tr>
<th>Variable cost per quarter per customer</th>
<th>New Customer</th>
<th>Existing customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marketing</td>
<td>5,000</td>
<td>1,000</td>
</tr>
<tr>
<td>On site activities</td>
<td>5,000</td>
<td>1,000</td>
</tr>
<tr>
<td>Total</td>
<td>10,000</td>
<td>2,000</td>
</tr>
</tbody>
</table>

Table 3: Variable cost per quarter per customer

7.8 Price Point

We plan to price our product and services competitively when compared to the market while offering equal or better cost savings in sourcing. The pricing strategy is to price the software and services separately. The price for the software package is $60,000 which includes one
quarter of free consultancy services which is very competitive when compared to average upfront price of $500,000 for business process outsourcing (T+D, 2007). The consultancy services will be charged at $20,000 per quarter which is very competitive when compared to $100,000 to $200,000 being charged for consultancy services. The reduced cost of services owes much to our optimization technology as its ease of customization makes it possible for the consultants to serve more customers concurrently when compared to competition.

The pricing strategy for different steps is shown below in the table as well.

<table>
<thead>
<tr>
<th></th>
<th>Sourcing optimization software</th>
<th>60,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Sourcing optimization services</td>
<td>20,000</td>
</tr>
</tbody>
</table>

**Table 4: Pricing Strategy for software and services**

Our initial estimate for product development is 6 months. Our target is to have only two customers in the first quarter after product introduction. This is to ensure that our Engineering organization will have enough bandwidth to cope with issues that may arise from the first couple of software installations and services. We hope to add more customers in following quarters. We plan to keep the cost structure such that the company will have positive cash flow within a year of the launch of the product and services. As shown in the next section, with this pricing structure we should be able to provide over ten times return in 5 years.
7.9 SWOT Analysis

SWOT analysis tool is very useful in understanding the business and making decisions. It is a very useful in reviewing an idea and come up with appropriate business strategy. SWOT stands for Strength, Weakness, Opportunity, and Threats. Strength and Weakness are usually internal to the organization while Opportunity and Threats are external to the organization. Based on our study the SWOT report for our company was as follows.

Strength

Better sourcing technology.

Lower Cost when compared to competition.

Closer to large manufacturing base

Strong management team

Weakness

New entrant to the market.

Cannot be applied efficiently in very small operations

No established customer base

Opportunities

Vertically independent sourcing optimization model that can be easily customized across various domains.

Most of the manufacturing is increasingly distributed and can benefit from this solution

Threats

Competition

New Technology

Recession
Competition for people

7.10 Investment Capital Requirement

Based on our cost estimates and revenue projection we will need an investment capital of $1.2 million dollars. Out of $1.2 million, $515,000 is needed to setup the company operations while the rest will be needed over next three quarters to account for the negative cash flow. The projected balance sheet for each quarter is shown below. As shown in the balance sheet, we estimate a negative cash flow of $350,000, $214,000 and $122,000 during the subsequent quarters which needs to be covered through capital infusion from our investors.

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Fixed Cost</th>
<th>Cost of Acquiring New Customers</th>
<th>Cost of Retaining Existing Customers</th>
<th>Total Cost</th>
<th>Total Revenue</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q2 11</td>
<td>515,000</td>
<td>-</td>
<td></td>
<td>515,000</td>
<td>0</td>
<td>-515,000</td>
</tr>
<tr>
<td>Q3 11</td>
<td>450,000</td>
<td>20,000</td>
<td>-</td>
<td>470,000</td>
<td>120,000</td>
<td>-350,000</td>
</tr>
<tr>
<td>Q4 11</td>
<td>450,000</td>
<td>40,000</td>
<td>4,000</td>
<td>494,000</td>
<td>280,000</td>
<td>-214,000</td>
</tr>
<tr>
<td>Q1 12</td>
<td>480,000</td>
<td>50,000</td>
<td>12,000</td>
<td>542,000</td>
<td>420,000</td>
<td>-122,000</td>
</tr>
<tr>
<td>Q2 12</td>
<td>480,000</td>
<td>60,000</td>
<td>22,000</td>
<td>562,000</td>
<td>580,000</td>
<td>18,000</td>
</tr>
<tr>
<td>Q3 12</td>
<td>510,000</td>
<td>60,000</td>
<td>34,000</td>
<td>604,000</td>
<td>700,000</td>
<td>96,000</td>
</tr>
<tr>
<td>Q4 12</td>
<td>510,000</td>
<td>60,000</td>
<td>46,000</td>
<td>616,000</td>
<td>820,000</td>
<td>204,000</td>
</tr>
<tr>
<td>Q1 13</td>
<td>540,000</td>
<td>60,000</td>
<td>58,000</td>
<td>658,000</td>
<td>940,000</td>
<td>282,000</td>
</tr>
<tr>
<td>Q2 13</td>
<td>570,000</td>
<td>60,000</td>
<td>70,000</td>
<td>700,000</td>
<td>1,060,000</td>
<td>360,000</td>
</tr>
</tbody>
</table>
Table 5: Quarterly Profit and Loss estimates

The yearly estimates for profit and loss are shown in the bar graph below.
### Figure 24: Yearly Profit/Loss Estimate

#### 7.11 Personal

For setting up the company a CEO will be hired. The CEO will be expected to hire the management team. The management team is expected to have a Vice President of Sales and Marketing and, Vice President of Engineering. Human Resources Manager, an accountant,
and an Administrative assistant will be hired to assist the team in hiring and other operational activities,

The VP’s are expected to setup their individual teams. We plan to hire two software development engineers, one quality assurance engineer, and consultant engineers reporting to the VP of Engineering. Similarly we plan to hire a sales and marketing executive to assist the VP in sales.

7.11.1 Chief Executive Officer

A Chief Executive Officer will be hired to setup and run the company. The CEO should have good management experience and preferably have sales and marketing experience in services industry. An executive having an established network with businesses in the valley will be an absolute plus as it will help the company in building its customer base.

7.11.2 Vice President of Sales and Marketing

Vice President of Sales and Marketing will be responsible for the business development activities of the company. An executive with an established business network will be preferred as it will help the company in establishing relationship with potential customers. Understanding of the global business will be an added bonus as it will help the company reach out to potential customers outside the valley.

7.11.3 Vice President of Engineering

Vice President of Engineering will be responsible for the Research, Development, and professional services. An executive with technical background and management experience will be an ideal candidate for the position. His responsibility includes developing our intellectual property further to maintain our competitive advantage. He will also responsible
for the software development, and quality assurance of the product. We also intend to have
the consultancy services under the VP for the R&D engineers and consultants to benefit from
each others knowledge and experience.

7.11.4 Human Resources

Employees are our key assets. Without a dedicated Human Resources Manager we may find
it difficult to attract and retain the best talent available. Manager with past experience in a
startup with strong motivational skills will be preferred.

7.11.5 Accountant

Managing the cash flow is critical for us maintain accountability to our share holders and to
comply with local, state, and national regulations. We plan to hire an experienced accountant
for the task.

7.11.6 Product development engineer

The product development engineer will play a key role in not only implementing the
mathematical model into a software package, but also will be expected to follow the
advances in the field of supply chain optimization. Engineers with strong background in
statistics and software programming will be preferred.

7.11.7 Quality Assurance Engineer

Quality assurance engineers will work closely with the development engineers to develop test
cases and execute them. He is expected to work with the consultant to identify the use case
scenarios. Engineers with experience in testing algorithms and developing test automation
scripts will be the preferred candidates.
7.11.8 Consultant Engineer

Consultants will be our interface to the customers. They are expected to analyze the sourcing data with our tools and advise on appropriate strategy to be followed.

7.12 Business and Revenue Model

As mentioned before, our business is based on selling our optimization software and providing consultancy services. Most of the costs associated with the business are fixed costs while variable costs are mainly associated with marketing and sales.

Our target is to add 6 new customers each quarter while striving to retain existing customers.

The table below shows the projected balance sheet for next five years.

<table>
<thead>
<tr>
<th></th>
<th>Q211 to Q1 12</th>
<th>Q2 12 to Q1 13</th>
<th>Q2 13 Q1 14</th>
<th>Q2 14 to Q1 15</th>
<th>Q2 15 to Q1 16</th>
<th>Q2 16 Q1 17</th>
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</thead>
<tbody>
<tr>
<td><strong>Revenue</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New sales</td>
<td>660,000</td>
<td>1,440,000</td>
<td>1,440,000</td>
<td>1,440,000</td>
<td>1,440,000</td>
<td>1,380,000</td>
</tr>
<tr>
<td>Consultancy Services</td>
<td>160,000</td>
<td>1,600,000</td>
<td>3,520,000</td>
<td>5,440,000</td>
<td>7,360,000</td>
<td>9,280,000</td>
</tr>
<tr>
<td><strong>Total Projected Revenue</strong></td>
<td>820,000</td>
<td>3,040,000</td>
<td>4,960,000</td>
<td>6,880,000</td>
<td>8,800,000</td>
<td>10,660,000</td>
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<tr>
<td><strong>Fixed Costs</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expenses</td>
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<td></td>
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<td>12,000</td>
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<td>12,000</td>
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<td>Office equipment</td>
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<td>12,000</td>
<td>12,000</td>
<td>12,000</td>
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<td>--------</td>
<td>--------</td>
<td>--------</td>
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<td>Telephone and Internet</td>
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<td>8,000</td>
<td>8,000</td>
<td>8,000</td>
<td>8,000</td>
<td>8,000</td>
</tr>
<tr>
<td>Total Fixed Costs</td>
<td>185,000</td>
<td>120,000</td>
<td>120,000</td>
<td>120,000</td>
<td>120,000</td>
<td>120,000</td>
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<td>Wages</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CEO</td>
<td>200,000</td>
<td>200,000</td>
<td>200,000</td>
<td>200,000</td>
<td>200,000</td>
<td>200,000</td>
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<tr>
<td>VP Engineering</td>
<td>160,000</td>
<td>160,000</td>
<td>160,000</td>
<td>160,000</td>
<td>160,000</td>
<td>160,000</td>
</tr>
<tr>
<td>VP Marketing</td>
<td>160,000</td>
<td>160,000</td>
<td>160,000</td>
<td>160,000</td>
<td>160,000</td>
<td>160,000</td>
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<tr>
<td>Sales and Marketing</td>
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<td>120,000</td>
<td>120,000</td>
<td>120,000</td>
<td>120,000</td>
<td>120,000</td>
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<tr>
<td>Product Development</td>
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<td>200,000</td>
<td>200,000</td>
<td>200,000</td>
<td>200,000</td>
<td>200,000</td>
</tr>
<tr>
<td>Engineers (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality Assurance</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
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<td>HR</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
</tr>
<tr>
<td>Accounting</td>
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<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
</tr>
<tr>
<td>Administrative</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
<td>60,000</td>
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<tr>
<td>Employee Benefits</td>
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<td>360,000</td>
<td>360,000</td>
<td>360,000</td>
<td>360,000</td>
<td>360,000</td>
</tr>
<tr>
<td>Customers</td>
<td>11</td>
<td>35</td>
<td>59</td>
<td>83</td>
<td>107</td>
<td>130</td>
</tr>
<tr>
<td>Consultant Engineer, one</td>
<td>100,000</td>
<td>240,000</td>
<td>440,000</td>
<td>640,000</td>
<td>780,000</td>
<td>920,000</td>
</tr>
<tr>
<td>for 10 customer Benefits</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Wages</td>
<td>1,710,000</td>
<td>1,920,000</td>
<td>2,220,000</td>
<td>2,520,000</td>
<td>2,770,000</td>
<td>2,960,000</td>
</tr>
<tr>
<td>Total Fixed Expenses</td>
<td>1,895,000</td>
<td>2,040,000</td>
<td>2,340,000</td>
<td>2,640,000</td>
<td>2,890,000</td>
<td>3,080,000</td>
</tr>
<tr>
<td>Variable Costs</td>
<td>Sales Expenses</td>
<td>126000</td>
<td>400,000</td>
<td>592,000</td>
<td>784,000</td>
<td>976,000</td>
</tr>
<tr>
<td>----------------</td>
<td>---------------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>Total Expenses</td>
<td></td>
<td>2,021,000</td>
<td>2,440,000</td>
<td>2,932,000</td>
<td>3,424,000</td>
<td>3,866,000</td>
</tr>
<tr>
<td>Gain/Loss</td>
<td>(1,201,000)</td>
<td>600,000</td>
<td>2,028,000</td>
<td>3,456,000</td>
<td>4,934,000</td>
<td>6,422,000</td>
</tr>
</tbody>
</table>

Table 6: Projected balance sheet

From the balance sheet, we expect to have a positive cash flow after the first year. During the first year we will need a cash investment of $1.2 million dollars. If we consider a time value of money of 6%, the present value of money over next 5 calendar years will be $13,979,756.88. Forecasted return on investment for time value of money of 0% and 6% are shown in the graph below.

![Forecasted Return On Investment at 0% and 6%](image)

Figure 25: Forecasted Return on Investment
7.13 Strategic Alliances/Partners

Being a startup organization our product and services does not cover end to end supply chain needs that includes value added services like business process outsourcing. We will explore strategic alliances and partnership with other companies that can help us fill the gaps in our product and hence have opportunity to address a wider customer base.

7.14 P&L

As discussed before in the revenue projections, we expect to make losses during the first four quarters of operation. Hence we will need additional capital from our investors to account for the negative cash flow in the first four quarters of operation. The projected profit and loss for the first six quarters are show in the table below.

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Fixed Cost</th>
<th>Cost of Acquiring New Customers</th>
<th>Cost of Retaining Existing Customers</th>
<th>Total Cost</th>
<th>Total Revenue</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q2 11</td>
<td>515,000</td>
<td>-</td>
<td>515,000</td>
<td>0</td>
<td>-515,000</td>
<td></td>
</tr>
<tr>
<td>Q3 11</td>
<td>450,000</td>
<td>20,000</td>
<td>470,000</td>
<td>120,000</td>
<td>-350,000</td>
<td></td>
</tr>
<tr>
<td>Q4 11</td>
<td>450,000</td>
<td>40,000</td>
<td>494,000</td>
<td>280,000</td>
<td>-214,000</td>
<td></td>
</tr>
<tr>
<td>Q1 12</td>
<td>480,000</td>
<td>50,000</td>
<td>542,000</td>
<td>420,000</td>
<td>-122,000</td>
<td></td>
</tr>
<tr>
<td>Q2 12</td>
<td>480,000</td>
<td>60,000</td>
<td>562,000</td>
<td>580,000</td>
<td>18,000</td>
<td></td>
</tr>
<tr>
<td>Q3 12</td>
<td>510,000</td>
<td>60,000</td>
<td>604,000</td>
<td>700,000</td>
<td>96,000</td>
<td></td>
</tr>
</tbody>
</table>

Table 7: Projected Profit and Loss

As mentioned before two main streams of revenue are from selling the software to new customers and then the consultancy services. Hence for the success of the company it is very important to retain our new customers to whom we sold the product as customers for consultancy services as well.
7.15 Return On Investment (ROI)

Return on Investment (ROI) is a commonly used metrics to evaluate financial benefits of various investment decisions. Higher the expected ROI, higher the probability that an investor is willing to invest in a venture. For our venture, the expected return of investment over a five year period is

\[
\frac{16,239,000.00}{1,200,000} - 1 = 12.5
\]

7.16 Exit Strategy

We want to start selling our product and services to semiconductor and hi-tech industries, which dominate the Silicon Valley, landscape and later take it to other verticals such as retail goods manufacturing. The success of our organization will depend on how successful our initial customers will be in optimizing their sourcing. In the case of us not getting enough traction in the market, we would try to join a larger consulting group as technical and business partners.
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