Unlocking Value added services in Bio-Pharmaceutical industry
Team: Raúl Carrasco, Swagat Panda
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Inventory Optimization as a Business Advantage
Team: Christos Agrogianis, Rajesh Kella
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Building a Segmented Cost-To-Serve Model
Team: Tyler Martin, Lucía Milián
Advisor: Alejandro Serrano

Strategy for Pharma Business Expansion in Sub Saharan Africa: A Case Study for Kenya
Team: Mohamed Bah, Ana Gauthier, Wen Qi
Advisor: Spiros Lekkakos
Introduction

Welcome to the 2016 MIT Zaragoza Master of Engineering in Logistics and Supply Chain Management (ZLOG) Research Journal!

The four papers included in this journal were chosen from the nine theses submitted by the ZLOG class of 2016 at the Zaragoza Logistics Center. The articles are written as executive summaries and are intended for a business, rather than an academic audience.

The purpose of the executive summaries is to give the reader a sense of the business problem being addressed, the methods used to analyze the problem, and the relevant results, conclusions and insights gained. The complete theses are, of course, much more detailed. We have also included a complete list of this year’s ZLOG theses with short descriptions at the end of this journal.

The articles in this publication cover a wide range of interests, approaches, and industries. This variety of topics illustrates one of the hallmarks of the ZLOG program: the students’ ability to focus their course work and research on topics that most interest them.

The ZLOG program is designed for early to mid-career supply chain professionals who want a more in-depth and focused education in supply chain management, transportation and logistics.

All projects are conducted in conjunction with the Zaragoza Academic Partner (ZAP) Program, an initiative to enhance applied research and closer industry-academia relationships in the field of supply chain management.

The ZAP Program gives ZLOG students the opportunity to work closely with industry professionals on actual supply chain problems, and gives companies an opportunity to interact with a student or student team along with a professor as expert thesis advisor who together bring new insights and approaches to a current supply chain project.

We hope you enjoy the articles. If you wish to discuss any other aspect of the ZLOG program or wish to find out how your company can interact with ZLOG students, please do not hesitate to contact me directly.

Happy reading!

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KEY INSIGHTS

1. In general, cancer patients are becoming increasingly aware of different aspects related to their treatment. They are demanding information transparency and are more than willing to be involved in their treatment journey.

2. Technology is the core to most of the value added service (VAS) models currently available in market.

3. The key focus for any immuno-oncology service model should be the patient health monitoring between two infusion (drug administration) appointments.

4. It is imperative to collaborate with other stakeholders like physicians, pharmacists, and healthcare providers etc. to deliver VAS more effectively. A robust value proposition must be defined to incentivize them to collaborate with the bio-pharmaceutical company.

Within this scenario, a bio-pharmaceutical global leader (BPC) is trying to understand the unmet patient needs in immuno-oncology space and how they can devise a service strategy to meet those needs with compliance. This thesis is a humble attempt to close this gap and help the industry evolve with innovative service offerings. The scope of the project is limited to immuno-oncology space in France, which is a key market for the sponsoring company.

If a robust service strategy can be devised and implemented, it will not only give a competitive advantage to the sponsoring company, but will drive the industry forward towards the ultimate goal of making life easier for patients.

Methodology

We started with thorough literature review, which was done to understand the current VAS landscape in biopharmaceutical industry. Apart from this, a competitive benchmarking was performed with 11 close competitors. In the best interest of the thesis, we did not limit our competitors to only immuno-oncology area as we realized that we may come across many nice examples of VAS from other therapeutic areas as well.

Later, we conducted face to face and telephonic interviews with many healthcare professionals from France and Spain, over a period of 3 months. We had 12 such interviews in Barcelona and 6 in Paris. Apart from this, telephonic interviews were also conducted with professionals in Barcelona and Madrid, whenever it was deemed necessary.

Introduction

The emerging long-term picture of bio-pharmaceutical industry is exciting, with many disruptive innovations. However on a long term, a biopharmaceutical company has to maintain competitiveness by ensuring affordability, quality, and delivery performance. [Mckinsey Report: Otto et al. 2014].

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Also, separate questionnaires were designed for prescribers and hospital pharmacists in France. Although we could not complete the survey in time due to legal complications, the questionnaires have been included as a part of the thesis for future reference.

Models developed

Based on both primary and secondary research, we developed the service models for the two intended service channels (Direct to patient via IT model, collaboration model with healthcare providers).

Model 1- Direct to patient via IT Model (Mobile APP)

Our proposed APP platform is a comprehensive service bundle, which is currently not available in the market.

As shown in Figure 2, the idea is to link the de-identified portion of the data, retrieved from the Hospital ERP to the mobile APP. Critical data elements like adherence data, side effects data etc. can flow both to backend database administrators as well as Hospital ERP. A healthcare coach or hospital pharmacist can make use of this data to help the patients in their journey. This unique model, if applied on the principles of data security, forms the backbone of our value added service (VAS) offerings. The six VAS offering for which we have developed functional specifications are “Treatment adherence”, “Appointments support”, “Possible Drug interaction”, “Side effects Management”, “Patient education and management” and “Oncology updates”. We also performed a NPV analysis for this investment, taking in to account the additional revenue due to expected increase in adherence.

Model 2- Collaboration with healthcare providers

When a patient, visiting a hospital, is prescribed immuno-oncology product, he/she is automatically entitled to all the services offered by the proposed “Integrated Care Centres”. The Hospital is expected to provide the necessary infrastructure to carry out the operations. BPC is expected to take care of all expenses related to the salaries of full time oncologists, pharmacists, nurses, administrative staffs and psychologists etc., necessary to offer the intended services.

Our model is a win-win situation for all the key stakeholders (i.e., the patients, the hospital as well as BPC) as we have strong value proposition for all the parties involved.

Conclusion

We found that the amount of financial risk the company would subject itself with Model 1 investment is negligible. However the legal, regulatory, IT-security and brand image risks are significant and need to be factored. In Model 2, a strong value proposition exists for hospitals but convincing the key opinion leaders and overcoming the regulatory barriers are again the biggest challenges. However a pilot run can be carried out in Paris and then a decision can be taken if the model is scalable. Overall both the models are innovative and first of its kind for bio-pharmaceutical industry.

Cited Sources

Inventory Optimization as a Business Advantage

By Rajesh Kella & Christos Agrogiannis
Thesis Advisor: Mustafa Çağrı Gürbüz

Summary:
This thesis addresses the performance optimization of the supply chain network for a chemical company that has its manufacturing base in Europe and serves the customers in the Latin America. With an objective to achieve the right balance between net working capital and speed of response, the scope of the work includes studying the segmentation strategy, optimizing the inventory policy and modifying the supply chain network.

KEY INSIGHTS
1. Scientific methodology and tools fit perfectly with business strategic evaluations, mainly due to the possibility of building simulation models and analyzing different scenarios to support the decision making process.
2. Discrete Event Simulation (DES) is a powerful tool to evaluate the performance of the network configuration in uncertainty given the complexity of the Latin American market leading to non-stationary demand distributions.
3. Operational and financial decisions, like finding the right balance between Net Working Capital (NWC) and speed of response, should be made simultaneously to maximize the value for shareholders.

Introduction
In the wake of the collapse of Lehman Brothers in 2008 and the subsequent economic crisis, the nature of supply chain planning (inventory stocks, in-transit inventory and free-up of working capital) is at a center stage as never before. These economic failures did not only eradicate equity wealth for unlucky or irresponsible shareholders but also imposed system-wide risks for the entire supply chain due to diminishing available external source of investment. Inventory management can play a role in terms of generating cash instead from internal operations optimizing available working capital. To this end, companies are advised to focus on the operational side of the supply chain as an effort to increase their available working capital in the area of inventory management. Typically, a considerable amount of working capital is locked in current inventories due to forecast inaccuracies and oversized service level targets. This in turn unveils the criticality of effective inventory management in securing working capital and synchronizing product flows in light of demand and supply variability. As such, working capital is inextricably connected to having the right amount of inventory in the right place at the right time. Within this setting, inventory management seems not only to promise strengthening the working capital but also acting as a safeguard for customer satisfaction, supply continuity and financial growth that are critical for long term sustainable success for any organization.
The sponsoring company of this thesis project is a leading manufacturer in chemical industry with Business-to-Business (B2B) worldwide operations. The focus of this thesis project is on their operations in Latin America of one specific Business Unit (BU). The problem that the company anticipates is that the replenishment process of the warehouses in all the regions lacks transparency and differs from region to region. This leads to firefighting situations and requires a lot of manual and time consuming efforts from the managers. Optimal inventory levels are not known in every location. The present work sets out to unveil how the company in case could optimally utilize the current network configuration to minimize supply chain costs and potentially investigate an alternative (‘To-Be’) supply chain network configuration. To this end, our two guiding research questions are as follows:

a. What are the key factors influencing safety stock placement in a single/multi-echelon network?

b. What is the right balance between Net Working Capital (NWC) and the speed of response?

Methodology

Due to the large scope and multi-disciplinary aspect of the project involving data treatment, statistical analysis, mathematical modeling, stock policy development and simulation, a multi-stage roadmap was developed to tackle this problem and all steps to be followed are presented in the figure below.

- **Defining the Scope**
  - Understanding the scope and mapping the current supply chain network
  - Listing deliverables and the sponsor company’s expectations

- **Data Collection & Integration**
  - Data Collection & Cleaning up
  - Integration of Databases

- **Scope & Data Analysis**
  - Pareto analysis to downsize the scope to a manageable size
  - Descriptive Statistics to identify representative sample data without loss of generality

- **Modeling & Simulation**
  - Calculation of expected values of Supply Chain parameters
  - ARENA Simulation of proposed inventory policy
  - Supply Chain network configuration

The sponsor company’s expectation is to find the right balance between net working capital and the speed of response that gives them a competitive advantage. As per the current business dynamics in a B2B environment, customer orders are either fulfilled on-time from available stock or with the arrival of the next replenishment shipment. While the former constitutes a faster speed of response, the latter represents a slower speed of response and might lead to customer dissatisfaction in the short term and potential loss of customer in the long term. In other words, speed of response is measured by the percentage of On-Time In-Full (OTIF) fulfillment of the customer’s orders. Due to the large extent of this project, the scope has been limited only to Latin American markets, which is relatively small but also the most challenging from a supply chain perspective due to fluctuating demand, governmental regulations and macro-economic factors. There are 16 affiliate warehouses in 8 countries spread across Latin America to cater to demand from the respective regions. There also exists Global DCs in Europe which serve replenishment shipments according to the orders from affiliate warehouses in Latin America. The orders from the end-customers are directly shipped from the closest affiliate warehouse in Latin America. The scope of the project is confined to the replenishment strategy between Global DC in Europe to Affiliate warehouse in LatAm. This means, it is assumed that the manufacturing capacity is unconstrained within the scope of the project. Apart from optimizing the performance of Latin American supply chain network, the overall target of this project also includes preparation of a generic business model that will be utilized as a key value chain for a pilot business unit within the sponsor company.

A study was done to understand the interaction between the factors that impact NWC and Speed of Response. The factors considered are Forecast accuracy, Inventory Level, Transit Inventory, Target Service Level and Lead Time. The complex interactions between these factors are depicted in the below figure, which is the result of brainstorming sessions with supply chain experts. The arrow heads indicate the impact of the preceding factor on the succeeding factor and the symbol on top of the arrow head depicts the nature of impact. For example, improving forecasting system leads to higher forecast accuracy, which in turns reduces the uncertainty and hence the need to hold higher safety stock. Lower safety stock would lead to less capital tied in inventory thereby reducing NWC. Based on this study, we reached a conclusion that these factors can be directly controlled by three aspects of the Supply Chain – namely Segmentation Strategy, Inventory Policy (IP) and Network Design.
Segmentation

In order to differentiate the replenishment process for each SKU, the two factors considered are importance of SKU in sales and the predictability of demand. In order to study the importance of a product in a region, all SKUs are sorted by their Contribution Margin (CoMa) and classified into three categories – A, B & C- based on their profitability. While ‘A’ class SKUs are highly profitable, ‘C’ class represents the least profitable. Similarly, all SKU’s are classified into three categories – X, Y & Z – based on their forecast accuracy. While ‘X’ class represents most predictable SKUs, ‘Z’ class represents least predictable. The combination of these two classifications (A, B, C) & (X, Y, Z) results in 9 categories and their target service levels are present in the following table.

<table>
<thead>
<tr>
<th>TARGET SERVICE LEVELS</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>90%</td>
<td>75%</td>
<td>60%</td>
</tr>
<tr>
<td>Y</td>
<td>85%</td>
<td>70%</td>
<td>55%</td>
</tr>
<tr>
<td>Z</td>
<td>80%</td>
<td>65%</td>
<td>50%</td>
</tr>
</tbody>
</table>

The rationale behind these target service levels is to increase the net margin by increasing product availability for highly predictable SKUs while not holding too much of inventory as buffer stock for uncertainty. Hence, higher service levels are assigned to highly profitable and highly predictable (For example AX category) SKUs to generate higher net profits while lower service levels are assigned to least profitable least predictable SKUs to reduce working capital (for example, CZ category). It was learnt during the interviews with Sponsor Company personnel that, backorders do not become lost revenue and usually all backorders are fulfilled at a later date. The only risk is to lose the customer due to repeated delay in fulfillment of orders. Hence, within a profitability category (for example, Category A), precedence is given to the holding costs over underages costs (such as lost sales) – leading to assigning higher target service levels for AX when compared to AZ.

Inventory Policy (IP)

The inventory planning process establishes the optimal inventory levels that must be maintained at affiliate warehouse to meet expected service levels for demand fulfillment. The model used for modeling and simulation is the Order up-to level with a periodic review. Not only this is the best policy for a joint replenishment inventory systems (Viswanathan, S. 1997), but also the preferred mode of inventory policy from the sponsor company due to practical constraints on human resources and IT infrastructure. Descriptive statistics showed that the demand doesn’t follow a normal behavior irrespective of aggregating on daily, weekly or monthly basis. Discrete Event Simulation (DES) model is built to examine various types of inventory policies in ARENA software. The inputs to the DES model include – demand, forecast, lead time and target service level. The model is configured to simulate three different types of inventory policies – Normality, Stationary optimization & Evolutionary optimization.

In an IP based on Normality, the demand is assumed to follow Normal distribution, in which case, important parameters can be calculated as given below.

\[ \sigma_{LT} = \sigma_f \cdot (L+T) \]
\[ SS = F-1(CSL;0;1) \cdot \sigma_{LT} \cdot 1.25 \]
\[ OUL = DT+L + SS \]
\[ Expected Transit Inventory = D \cdot L \]
\[ Expected On-hand Inventory = OUL - DT+L + Expected Backorder \]

| \( L \) | Lead time for replenishment
| \( \sigma_f \) | Mean Absolute Deviation during L+T periods
| \( D \) | Demand Forecast per unit time
| \( SS \) | Safety Stock

An IP based on Stationary optimization, Opt Quest module, equipped with ARENA software, is used to perform non-linear optimization. The objective of the optimization is to arrive at the optimum safety stock while minimizing the Total cost, which is the sum of Inventory holding cost and Transportation cost, and meeting the target service levels. It is called as Stationary model because though the overall business of the sponsor company had gone through many changes with time, the SS remains constant across the time period of the simulation. But significant
changes to business dynamics calls for changes in two keys aspects of the supply chain model – the segment the combination belongs to and the amount of safety stock. The change in segment over time in one case is illustrated in the figure below.

The size of the bubble represents the annual volume and it is plotted over Contribution Margin (X-axis) and MAPE (Y-axis). Hence the Cartesian plane is divided into 9 segments and we can see how the given combination jumps different categories in different years.

In an IP based on evolutionary optimization, SS is allowed to be updated on a periodic basis as we learn more about the business trends. It is worth noting that the number of decision variables significantly increase in evolutionary models when compared to a stationary model. This makes it not only computationally more challenging but also more time-consuming. There are two types of evolutionary optimization approaches. Multi-variate evolutionary optimization can be considered similar to running many stationary optimizations simultaneously for every period, as the SS is allowed to be updated. Whereas with the exponential-smoothing based evolutionary optimization, the only difference is that SS is a derived variable that is calculated by the equation below, unlike models where SS is an output of optimization.

\[
SS = \alpha \times SS_B + (1 - \alpha) \times \varepsilon_{L+T}
\]

Where:
- SS = Safety stock for a given time period – a month in this case
- \(\alpha\) = Exponential smoothing constant, a value between 0 and 1
- SS_B = Base safety stock, a constant
- \(\varepsilon_{L+T}\) = Forecast error in the past (L+T) period

The two extremes of the proposed policy are when \(\alpha = 0\) or 1. When \(\alpha = 1\), SS = SS_B, which is a constant. In other words, \(\alpha = 1\) represents a passive stationary model where SS doesn’t change with time. On the other hand, when \(\alpha = 0\), SS = \(\varepsilon_{L+T}\). This indicates an extremely reactive model that updates SS every month according to the forecast error of past (L+T) periods. The proposed evolutionary model under exponential smoothing (where \(0 < \alpha < 1\)) is a middle ground between the two aforementioned passive-reactive extreme models. In this scenario, the Opt Quest module of ARENA is used to find optimum values of \(\alpha\) and SS_B while minimizing the total cost under the constraint of meeting the target service levels for the given time period.

The figure below depicts graphically depicts the reduction in inventory levels in one case through adoption of different aforementioned models.

While AS-IS represents the current average annual inventory level held by the sponsor company, Perfect information represents the expected average annual inventory when we have perfect information of arriving demand, i.e. forecast = demand eliminating the need for safety stock. The objective is to get as close as possible towards average annual inventory of perfect information from the AS-IS scenario. More detailed results of the 20 combinations from all the models are compiled in the below table.

<table>
<thead>
<tr>
<th>Combination</th>
<th>Average Total Inventory</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS-IS (1)</td>
<td>Normality (2)</td>
</tr>
<tr>
<td>Stationary (3)</td>
<td>Evolutionary Model (4)</td>
</tr>
<tr>
<td>Evolutionary Information (5)</td>
<td>Perfect Information (6)</td>
</tr>
<tr>
<td>1</td>
<td>39.292</td>
</tr>
<tr>
<td>3</td>
<td>20.499</td>
</tr>
<tr>
<td>4</td>
<td>32.184</td>
</tr>
<tr>
<td>5</td>
<td>32.060</td>
</tr>
<tr>
<td>6</td>
<td>36.708</td>
</tr>
<tr>
<td>10</td>
<td>23.301</td>
</tr>
<tr>
<td>12</td>
<td>23.761</td>
</tr>
<tr>
<td>13</td>
<td>25.491</td>
</tr>
<tr>
<td>14</td>
<td>17.586</td>
</tr>
<tr>
<td>17</td>
<td>32.725</td>
</tr>
<tr>
<td>18</td>
<td>3.943</td>
</tr>
<tr>
<td>19</td>
<td>7.636</td>
</tr>
<tr>
<td>20</td>
<td>6.025</td>
</tr>
</tbody>
</table>

While implementing normality-based inventory system might give marginal benefits from current inventory levels in certain cases, stationary & evolutionary models present much more benefits by reduction in inventory by over 25% and 32% respectively from the current scenario.

Network Configuration

Simulations were run with the top SKU and stationary model is adopted to understand the impact
of adding a DC on inventory levels and costs. Due to nature of the Sponsor Company’s business model, adding a DC is not going to eliminate the need of running regional warehouses for two reasons. First, the regional warehouse serves all the Business Units of the Sponsor Company not just the one within the scope of this project. Secondly, serving end customers directly from DC is extremely difficult given the acceptable lead time to the customer is less than a week and it usually takes more than 10-30 days on average for custom clearances in Latin America. The results of the simulations are compiled in the following table.

<table>
<thead>
<tr>
<th>FACILITY</th>
<th>Replenishment Point</th>
<th>Inventory Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>On Hand</td>
<td>Transit</td>
<td>Total</td>
</tr>
<tr>
<td>Argentina</td>
<td>Europe</td>
<td>31.28</td>
<td>24.05</td>
</tr>
<tr>
<td>Brazil</td>
<td>Europe</td>
<td>45.78</td>
<td>11.42</td>
</tr>
<tr>
<td>Mexico</td>
<td>Europe</td>
<td>3.44</td>
<td>11.94</td>
</tr>
<tr>
<td>Chile</td>
<td>Europe</td>
<td>1.15</td>
<td>2.24</td>
</tr>
<tr>
<td>Colombia</td>
<td>Europe</td>
<td>2.25</td>
<td>5.00</td>
</tr>
<tr>
<td>Mexico</td>
<td>DC</td>
<td>21.32</td>
<td>18.85</td>
</tr>
<tr>
<td>Brazil</td>
<td>DC</td>
<td>5.47</td>
<td>2.20</td>
</tr>
<tr>
<td>Mexico</td>
<td>DC</td>
<td>1.39</td>
<td>1.50</td>
</tr>
<tr>
<td>Colombia</td>
<td>DC</td>
<td>1.69</td>
<td>1.60</td>
</tr>
<tr>
<td>Mexico</td>
<td>DC</td>
<td>15.38</td>
<td>18.62</td>
</tr>
<tr>
<td>Brazil</td>
<td>DC</td>
<td>2.00</td>
<td>1.50</td>
</tr>
<tr>
<td>Mexico</td>
<td>DC</td>
<td>1.50</td>
<td>1.50</td>
</tr>
<tr>
<td>Colombia</td>
<td>DC</td>
<td>3.00</td>
<td>3.00</td>
</tr>
</tbody>
</table>

Though the amount of safety stock required at each facility has decreased by virtue of aggregation and reduction in lead times by adding a DC, we’ve observed an increase in total inventory levels and total costs after adding a DC when compared to before. This could be explained by two reasons. First, increase in inventory levels despite decrease in safety stock is attributed to increase in number of stocking locations. For example, inventory for catering to Argentinian demand is stored in both DC and then in the warehouse in Argentina. Secondly, increase in transportation costs is attributed to overall increase in ton-miles due to addition of another node in the supply chain network. Also, there would be additional costs of running a DC that are not captured in the simulation. From this analysis, we recommend against adding a DC in Latin America.

**Conclusion**

This thesis project emphasizes how multi-step approaches are able to breakdown larger problems and handle large amounts of data, whilst keeping the results accurate. In addition, it is evidence that scientific methods and tools such as discrete event simulation can not only be used to support or validate companies’ decisions but also to optimize them. Throughout the thesis, many different tool and techniques such as probability distributions, demand aggregation, stock policies, discrete event simulation and non-linear optimization were used in order to handle the data and enable us to build models and propose recommendations. This clearly poses the multi-disciplinary aspect not only of our project, but also of many supply chain related challenges that companies need to meet on a daily basis.

Latin American market is relatively small but more challenging from supply chain standpoint due to complexity driven by non-stationary demand distributions. Descriptive statistics showed that the demand doesn’t follow normal behavior irrespective of aggregating on a daily, weekly or monthly basis. The evolutionary inventory models and dynamic segmentation discussed in the thesis would help the sponsor company to plan better with these non-stationary non-normal demand distributions. Consequently, the output of the non-linear optimization of the DES Models presents the optimal safety stock for the Sponsor Company’s current network. Three different models were discussed for inventory policy – Normality, Stationary & Evolutionary optimization each having not only increasing benefits of inventory levels and costs but also increasing difficulty in consistent implementation in large organizations. Our proposal to the company in the short term and long term will optimize their costs, however, preliminary results recommend against opening a centralized distribution center in Latin America due to the increase in both inventory levels and costs.

**Cited Sources**

Building a Segmented Cost-To-Serve Model

By Tyler Cheever Lewis Martin & Lucía Milián Ariño
Thesis Advisor: Alejandro Serrano, Ph.D. Supply Chain Management

Summary: A cost-to-serve analysis was used to create visibility into supply chain costs of a major manufacturer of medical sutures. An interactive data tool was built in Tableau to allow visualization of the data and provide calculators to perform scenario simulations.

Introduction

A CTS analysis is a process to quantify the costs of activities, engaged in by a company, in order to fulfill customer demand for a product through the end-to-end supply chain. This excludes costs that are absorbed into the cost of goods and instead looks at activities that do not add direct value to the product (i.e., make up in-direct costs). The total costs of these activities must be allocated to specific products or families of products relative to their consumption. This allows for visibility into the costs which are specific to the given product or product family. This can be done in terms of volume ratios, time ratios, or other measures of consumption.

Objectives

The primary research objective of this thesis is to develop a CTS model to identify how each activity, undertaken to get a product to its customer, contributes to the overall reduction in gross profit for that product. A good way to think of it is to consider creating an income statement for a single product. The cost detail included in an income statement, at the product level, is similar to the visibility that a CTS analysis attempts to provide.

The first step in creating a model is to build the framework, which includes determining cost allocation methods and identifying which costs should be considered in the analysis. Next, it is essential to design a data gathering strategy and that can be executed in the given timeline. Once the data has been gathered, it will need to be integrated into a central location and displayed using data visualization software. The visualizations will need to demonstrate an ability to create segmentations and identify unique insights.

To summarize, the thesis objectives are:
1. Identify applicable cost drivers and the activities that make up the cost drivers
2. Create a methodology to allocate costs by product family and quantify activity costs
3. Segment data to allow drill down into various demographics (i.e., customer, distribution channel, final warehouse destination, and so on)
4. Build interactive dashboard to provide data visualization and unique insights

The expectation of these objectives is to reduce annual supply chain costs by $4M-$5.5M. This number was proposed by a major consulting firm after reviewing the balance sheet of the sponsor and comparing it to the savings of similar companies that have implemented supply chain visibility projects in the past.

A number of articles, including Supply Chain Brain (2015) and Braithwaite (1998), were consulted to understand the concept of a CTS analysis. Given that the concept is relatively new, there was less information to be found in published journals and textbooks. However, the resources that were available set the framework for turning the abstract vision into an actual model and tool.

**Implementation**

In order to begin the analysis, it is essential to identify which major costs are primary drivers behind the total cost of the supply chain. The cost drivers are not activities themselves, but instead they are aggregations of similar activities within the supply chain. For instance, if customer order changes are identified as a major cost, a potential cost driver may include change requests, emergency expediting, scrap and other activities related to customer order changes.

Supply chain scope and product need to be defined. For this specific case, interviews were performed with leaders across the supply chain planning department to identify cost drivers and the results were approved by stakeholders to make sure there was agreement within the organization. The cost drivers that were identified for this model are: Work Orders, Sales Orders, Setup Costs, Quality Control, Inventory Management, Distribution Packaging and Administration Costs.

The cost allocation method being used for this analysis is closely related to activity based costing (ABC), but designed from the ground up for the specific sponsor. ABC is a methodology used to calculate the cost of items by quantifying and allocating the activity specific costs of producing an item, rather than dividing the aggregated total cost by total production volume. This allows for the mapping of resource consumption to individual product.

**The Tool: An Interactive Dashboard**

Once the relevant cost driver data is gathered and the costs have been allocated appropriately, the results need to be displayed in a variety of ways to cater to both technical employees and executive level decision makers.

The solution was to offer an interactive dashboard with a suite of detailed tables and high-level visual metrics. Both the tables and visualizations should allow for drill-down and filtering by the user if applicable.

Once the initial Excel draft has been approved, a quick iteration process starts in order to identify the correct metrics. As these metrics solidify, the data and visuals will be migrated into the data visualization tool Tableau for a more seamless data visualization experience. The preliminary dashboards for both the Excel model and Tableau are shown below, while more detailed views can be found in the thesis.

![Figure 1: Preliminary CTS Excel Dashboard](image-url)
Identifying which metrics to display can often be challenging. There should be a limited number of key performance indicators (KPIs) that can quickly tell a story, provoke investigations and enable business decisions for the stakeholders. When proposing metrics, a logical categorization was used to make it easier to align the metrics to the strategic goals of the organization. In addition, a variety of metrics were offered in each category to help stakeholders home in on measurements that will be most useful for their organization.

Conclusions

With the framework established and the cost allocation methodology identified, the CTS model and tool were built up in a manner that goes beyond what can be found in most current text and articles. The contributions of this thesis include a relevant case study to explain the concepts of cost-to-serve, a strategy for data requirements, a framework for the execution of the analysis, identification of cost drivers and relevant activities, thought provoking data visualizations and metrics, and industry leading applications of the final results.

The contributions for the sponsor include a customized version of the industry contributions. This includes cost drivers and activities that are specific to the business of the sponsor, specific data requirements that will need to be gathered, built-to-order dashboard and metrics, and specific guidance on the next steps to completion.

Overall, the thesis has taken an abstract concept of creating supply chain visibility, and created a vision, designed a strategy to execute the vision, and launched implementation towards completion of the strategy.

The newly acquired information obtained from the CTS model can also be used to further expand the understanding of the company’s customer base and provide input into unique analyses that were not possible before, such as Customer Lifetime Value (CLV) and Segmentations.

Developing a CLV from a lifetime CTS model will make it possible to identify which customers are more favorable for investments to encourage retention and which customers are not as favorable. It can also help to segment customers for preferential services to improve satisfaction of the more desirable ones.

This research set out to develop a CTS model that could help the sponsor company to identify how each activity, in the process of getting a product to its customer, contributes to the overall reduction in gross profit for that product and how this information can be of use for making strategic business decisions such as customer segmentation.

Cited sources


Strategy for Pharma Business Expansion in Sub-Saharan Africa: A Case Study for Kenya

By Mohamed Bah, Ana Kathleen Gauthier, and Wen Qi
Thesis Advisor: Dr. Spyridon Lekkakos

Summary:
This thesis addresses the question of how far a global pharmaceutical company should vertically integrate with its downstream supply chain to properly balance risk and benefit in Sub-Saharan Africa. Considering the uncertainty and risks associated with doing business in this part of the world, a decision support and planning tool was developed to help project the likely financial impact and other business consequences of the sponsor company’s future actions in the region.

Introduction
As a global leader in the pharmaceutical industry, PharmaComp, the company profiled in this study, has the potential to realize significant value and competitive advantage in Africa; a continent where current growth projections by 2020 are comparable to those of China. Recent projections obtained by PharmaComp, show that by 2020 it is estimated that the population in Africa will reach 1.3 billion people. By then the per capita pharma spending is also expected to rise from the current 17.4 USD to about 40 USD.

Spurred by a rising spending power and by the mounting cost of fighting diseases, Africa’s healthcare spending was raised from $28.4 billion in 2000 to $117 billion in 2012 (Holt, Lahrichi, & Santos da Silva, 2015). Future projections of the continent’s business potential have shifted dramatically in recent years. As a result, Sub-Saharan Africa (SSA) has become a priority for many global pharmaceutical companies including PharmaComp. The company is now examining its current supply chain strategy for SSA in order to position itself as a future market leader in the region.

KEY INSIGHTS
1. Kenya is the country that shows the most promise as an option for business expansion in Sub-Saharan Africa.
2. Even in the case scenario of lower than expected demand and higher than expected currency devaluation, vertical integration leads to more benefits than the status quo.
3. There is value in implementing vertical integration in stages rather than all at once to maintain flexibility to adapt to uncertain market conditions.
region with a focus on increasing responsiveness to patients.

Comprised of 54 countries with a population of about a billion people, Africa offers huge consumer market potential for pharmaceutical companies. However the challenges for developing a sustainable market strategy are daunting and supply chain distribution is one of them.

To address these challenges, PharmaComp has recently launched a new strategy for Africa in an effort to expand its footprint on the continent. It plans to focus on 20 countries in a phased manner, having started with seven so called “Wave I” countries in 2015, with a particular focus on the “Wave IA” countries of Ghana, Nigeria, Kenya, and Côte d’Ivoire.

Yet for PharmaComp to truly realize the African Opportunity, it needs to fully understand the supply chain, including final price to patient, supply chain inefficiencies, barriers and opportunities for better distribution. It should also put in place effective mechanisms to ensure on-going understanding of the Sub-Saharan Africa distribution network.

**Problem Definition**

The objective of the thesis is to develop supply chain and business strategies that will enable PharmaComp to improve sales growth and access to more patients in SSA, while taking into consideration local business conditions, relevant risks, tradeoffs, and other options that could influence its decisions in the future. The company’s current drug distribution network is very fragmented and contains a large number of intermediaries, thereby limiting its ability to efficiently distribute quality products to patients in the region. Ultimately PharmaComp would need to take on more responsibility in the downstream supply chain by vertically integrating with a local partner in order to address core issues in its supply and distribution chain. This thesis sought to answer the question:

*How far should PharmaComp vertically integrate with their downstream supply chain to properly balance risk and benefit in Sub-Saharan Africa?*

**Methodology**

To achieve this goal, we structured our analysis as follows:

First, we explored academic and popular literature to identify best practices that have been implemented in SSA by pharma and non-pharmaceutical companies.

Second, by using a questionnaire that was distributed to PharmaComp internal staff and country representatives, we developed a benchmark to measure the downstream supply chain management. Feedback from the questionnaire suggested that many of the downstream problems are linked with lack of communication, cold chain failure, counterfeit drugs, and backlogs and stockouts, which could hopefully be improved upon with greater supply chain control.

Third, by using information from third party reliable sources (such as The World Bank, The World Health Organization, and The Heritage Foundation), we developed a scorecard to help compare and rank each of the Wave I countries in terms of risks and candidacy for business expansion. The countries were ranked on a scale from 1 to 5. Based on qualities like political and economic stability, logistical infrastructure, the state of the healthcare industry and the efficiency of trade, the scorecard indicated that Kenya is the Wave I country best suited for business expansion for PharmaComp. Thus Kenya was selected as a case study country for the remainder of the thesis.

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1 Wave I countries: Kenya, Nigeria, Ghana, Côte d’Ivoire, Gabon, Angola, and Ethiopia
Fourth, we conducted an As-Is Analysis to determine the company’s current position within SSA and to study projections of where business will be heading within the next several years in the region.

Finally, a series of scenarios consisting of different levels of vertical integration were selected to be evaluated further in the business case analysis. Controlling more of the supply chain would reduce cold chain failures, introduction of counterfeit drugs, and stock outs and backlogs; however, such a move could also require a high upfront investment in a market that may ultimately prove not to be profitable. In order to determine which level of vertical integration PharmaComp should consider moving forward, we selected three scenarios that incrementally increase the responsibility level. The three scenarios are described and depicted below:

1. **As-Is**: PharmaComp will continue to operate as it currently does, using direct shipments from Europe and having product changing hands at the country airport.

2. **Scenario I**: PharmaComp will invest in the creation of an affiliate company in the host country. With this new affiliate, PharmaComp will manage a warehouse of owned inventory within the country. They will also assume the risk that comes from selling their products in the local currency. Secondary distribution to customers will continue in the same way it is currently operating.

3. **Scenario II**: PharmaComp will invest in the creation of an affiliate company in the host company and also take responsibility for the distribution of products to their top customers. They will manage a warehouse of owned inventory, assume the risk of selling in a foreign currency, and also manage part of the secondary distribution.

Given the fact that the scorecard identified Kenya as the top candidate for SSA expansion, our Phase II analysis will focus on applying the above scenarios to the Kenyan distribution system.

A business tool was then developed to analyze these three scenarios and to project the likely financial impact and other business consequences of their implementation. Due to the level of inherent uncertainty and risk associated with investing in Sub-Saharan Africa, we used Monte Carlo sensitivity analysis and real options analysis as useful decision-making tools to provide a feel for how investment results might be affected by changes to the values of critical variables.

**Kenya Case Study Results**

*Price to Patient and Cold Chain Failure Improvement*

In addition to profitability, PharmaComp was also concerned with reducing price to patient and cold chain failure. When comparing the effect of the three scenarios on these two factors, it was clear that the higher the vertical integration, the greater the improvement in these two areas. In the As-Is scenario, based on mark-up information, the patient pays 217% of the original price that PharmaComp sells to distributors. In Scenario I, that number falls to 166%, and in Scenario II, the price to patient is the lowest at 136%.

![Price to Patient](Image)

Cold chain failure also improves with vertical integration, it is estimated that the As-Is Scenario sees failure in up to 20% of products, while Scenario I could lower this percentage to as little as 8%, and Scenario II could lower the percentage to as little as 2%.

![Cold Chain Failure](Image)

However, despite the benefits, Scenarios I and II also come with risks
NPV Comparisons

Another important result of the thesis is the comparison of the profitability of Scenario I and Scenario II based on changes in the expected demand and changes in the additional investment cost that would be required to implement Scenario II. In general, Scenario II is the better option for instances when demand is high and investment cost is low, and Scenario I is better for options when the realized demand is lower than expected and the investment cost required for Scenario II is higher.

<table>
<thead>
<tr>
<th>Extra Investment in Scenario II</th>
<th>Δ 1.5 M</th>
<th>Δ 1.6 M</th>
<th>Δ 1.7 M</th>
<th>Δ 1.8 M</th>
<th>Δ 1.9 M</th>
<th>Δ 2.0 M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Scenario II</td>
<td>Scenario II</td>
<td>Scenario I</td>
<td>Scenario I</td>
<td>Scenario I</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>Scenario II</td>
<td>Scenario II</td>
<td>Scenario I</td>
<td>Scenario I</td>
<td>Scenario I</td>
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</tr>
<tr>
<td>Medium High</td>
<td>Scenario II</td>
<td>Scenario II</td>
<td>Scenario II</td>
<td>Scenario I</td>
<td>Scenario I</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>Scenario II</td>
<td>Scenario II</td>
<td>Scenario II</td>
<td>Scenario II</td>
<td>Scenario I</td>
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</tbody>
</table>

Scenario I Sensitivity Analysis

Scenario I seemed like the method of operation that PharmaComp would most likely choose for Kenya, so this thesis evaluated the decision to implement Scenario I using Monte Carlo sensitivity analysis. The analysis took into account fluctuations in demand, currency devaluation, and operational costs. The findings were that even in cases of low realized demand, high currency devaluation, and increased operational costs, Scenario I still proved to be more profitable than the As-Is Scenario.

Furthermore, when examining contribution of each factor to the variance in the NPV (Net Present Value), the demand fluctuation was found to account for 62.2% of the variance. This means that out of all the uncertainty that was taken into account in this model, demand and market growth rate account for over half. Currency devaluation fluctuations were also shown to be an important part of PharmaComp's decision process because changes there can account for about one third of all the variation in the Scenario I trade off. However, changes in operational costs were found to be not so important. Rates could increase by up to 20% and these changes would account for less than 1% of the uncertainty.

Real Options Analysis

The final analysis performed in the Kenya Case Study is a real option analysis to determine the value of waiting until 2020 to make a decision to implement Scenario II. It considers that PharmaComp can either choose to implement Scenario II right away, or they can choose to implement Scenario I today and wait until there is more information about the market conditions to decide whether or not to implement Scenario II.

This analysis found that 68% of the time it was beneficial to wait until 2020.
circumstances of high demand and/or low investment cost. By waiting until 2020 to make a decision about Scenario II, PharmaComp is able to maintain some flexibility in their strategy.

**Conclusions**

Sub-Saharan Africa is a very fragmented region that faces challenges of poor infrastructure, inefficient trade, and political and economic instability. The decision of which country to select as a foothold in the region is an important one for PharmaComp to consider, and after building the Scorecard to compare the qualitative factors of the Wave I countries, we can conclude that Kenya is the country that shows the most promise as an option for the company to expand their business presence in the SSA region. Concurrently, we are also able to conclude that PharmaComp supply chain performance can be improved by increasing visibility and control over their downstream supply chain. Feedback from the Benchmark questionnaire indicates that many of the downstream problems are linked with lack of communication, cold chain failure, counterfeit drugs, and backlogs and stockouts. All of these problems could be improved upon if there were more supply chain visibility.

Our scenario analysis, which compared Scenario I and II as potential options for improving supply chain visibility, emphasized the importance of the effect of uncertainty in the decision. From our sensitivity analysis of Scenario I, we can conclude that even in the worst case of lower than expected realized demand and higher than expected currency devaluation, Scenario I is more profitable than the current state of operation. Nevertheless, Scenario II shows potential for even further benefit (both from a profit perspective and a price to patient perspective). However, through our performance of real options analysis, we can say that there is more benefit in waiting until 2020 than to implement Scenario II today. Four years from now, PharmaComp will have more information about the potential market and will be able to decide if it would be better to stay with the Scenario I option or move to using Scenario II.

**Recommendations for Further Study**

Regional cross-border trade is on the rise in Africa. African leaders have agreed to create the continent’s largest free trade zone known as The Tripartite Free Trade Area (TFTA). TFTA covers 26 African nations in Eastern and Southern Africa. Thus, a regional supply chain network is becoming more and more viable. Further research could be conducted by PharmaComp to consider ways to segment the market that could take advantage of a hub scenario. Considering investment, risk, and economic scale, a single-hub scenario could be an option for their regional network design. A real options analysis similar to the one performed in this thesis could be performed on a hub scenario to determine if it could be beneficial to move to convert Kenya into a hub or to wait until a later point in time to make that decision.

**Cited Sources**

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Chain Performance Using Analytics
Team: Vineeta Ahlawat, David Martinez
Advisor: JianJun Xu

This thesis tackles the research question of finding the root cause of service disruptions in supply chain of surgical medical devices affecting supply chain performance and reliability. The key performance indicator of supply chain performance can be observed in terms of customer service level. A backorder is occurring when the company cannot fulfill a customer order. A qualitative analysis was performed in several factors responsible for service disruption or backorders in the supply chain network. A detailed quantitative analysis is done to understand the relation and impact of forecast, raw material availability and production process on.

Analyzing Sourcing Networks for a Coffee Retailer
Team: Ludovic Bernad, Lina Romero
Advisor: Rafael Díaz

The purpose of this thesis is to understand the rationale behind current supplier selection for non-company operated stores in order to help uncover opportunities and areas for improvement by launching a survey and using the odds ratio analysis. This study can then be used as a basis for the company to maximize procurement leverage. In addition, it seeks to explore logistics solutions that can enhance either responsiveness or efficiency in the coffee retailer’s supply chain.

Determining the optimum Mode of Transport
Team: Dhrupad Bhavsar, José Luis Meri Celma
Advisor: Susana Val

This thesis aims to develop a holistic and analytical model for Mode of Transport (MOT) selection for a given product, origin-destination combination in a multi-objective environment while considering different factors affecting decision making, trade-offs applicable and applying unique and generic logistical constraints to each Mode of Transport (MOT). It also provides an optimal solution for consolidation of shipments considering the order pipeline at a given point in time.

This thesis also strives to deliver analysis and comparison of different modes of transport based on the total cost that will be incurred, time to deliver, maximizing asset utilization and minimizing holding costs over a period of time. Post validation of the model, it could be evaluated for integration in the sponsor’s ERP system.

Facilitating Horizontal Collaboration in Supply Chains
Team: Rochak Gupta, Connor Makowski
Advisor: María Jesús Sáenz

The thesis aims to develop horizontal collaboration to become more widely adopted across industries in future. Our research addresses the automotive and 3PL industries, but maintains a generic approach for applications across different industries. This research identifies the key drivers and barriers behind horizontal collaboration, contrasts and details current prominent horizontal collaboration practices in US and in Europe, identifies key areas of focus for companies looking at horizontal collaboration to improve their supply chain and develops a new system of facilitating horizontal collaboration in future in a manner that is more natural and sustainable.

SAM: Procurement Strategic Solutions
Team: Arturo Almeida, Dhiosa Muñoz
Advisor: Luca Urcioli

The purpose of this thesis is to identify the best supply chain network of exploration barite for the
South American (SAM) operations of a world-class oilfield service company in the market. We collaborated with the company’s sourcing department by developing an optimization tool and providing recommendations for the demand countries. We focused on identifying the components of the landed cost, analyzed them, and considered strategic factors that can enhance the supply chain network design.

**Unlocking Value added services in Bio-Pharmaceutical industry**  
Team: Raúl Carrasco, Swagat Panda  
Advisor: Çagri Gürbüz

This thesis aims to identify the kind of services patients would like to see coming their way. The authors used both primary and secondary research techniques to identify the unmet patient needs and subsequently developed two service models to deliver these services in an effective manner.

**Inventory Optimization as a Business Advantage**  
Team: Christos Agrogiannis, Rajesh Kella  
Advisor: Çagri Gürbüz

This thesis addresses the performance optimization of the supply chain network for a chemical company that has its manufacturing base in Europe and serves the customers in the Latin America. With an objective to achieve the right balance between net working capital and speed of response, the scope of the work includes studying the segmentation strategy, optimizing the inventory policy and modifying the supply chain network.

**Building a Segmented Cost-To-Serve Model**  
Team: Tyler Martin, Lucía Milián  
Advisor: Alejandro Serrano

A cost-to-serve analysis was used to create visibility into supply chain costs of a major manufacturer of medical sutures. An interactive data tool was built in Tableau to allow visualization of the data and provide calculators to perform scenario simulations.

**Strategy for Pharma Business Expansion in Sub Saharan Africa: A Case Study for Kenya**  
Team: Mohamed Bah, Ana Gauthier, Wen Qi  
Advisor: Spiros Lekkakos

This thesis addresses the question of how far a global pharmaceutical company should vertically integrate with its downstream supply chain to properly balance risk and benefit in Sub-Saharan Africa. Considering the uncertainty and risks associated with doing business in this part of the world, a decision support and planning tool was developed to help project the likely financial impact and other business consequences of the sponsor company’s future actions in the region.
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