Summaries of select research projects by graduates of the MIT-Zaragoza Master of Engineering in Logistics and Supply Chain Management (ZLOG)

Optimizing Operations of a Pharmaceutical Regional Distribution Hub under Varying Regulatory Environments
By Rami Arafat and Michael A. Margarucci II
Thesis Advisor: Dr. Prashant Yadav

Direct-to-Pharmacy Distribution in Spain: An Operational and Politico-economic Analysis
By Pedro Campos and Alvaro Galve
Thesis Advisor: Dr. Prashant Yadav

Bulk Storage: Postponement of Agricultural By-Products
By Hugo Castro
Thesis Advisor: Dr. Beste Kucukyazici

Portfolio of Strategies for Optimal Procurement of Platinum Group Metals (PGM) in the Automotive Industry
By Leo Tom Zachariah and Jihwang Chang
Thesis Advisors: Dr. David Gonsalvez and Dr. Mozart Menezes

Packaging Design’s Impact on Sales and Supply Chain in the Consumer Goods Industry
By Daniel Gross and Sergey Parfenov
Thesis Advisors: Dr. Alejandro Serrano and Marija Milenkovic-Jansson

Supply Chain Integration and Customer Relationship Orientation
By Chris McDuling
Thesis Advisor: Dr. Maria Jesus Saenz

Linking Financial Planning to Demand Planning
By Pavel Volosciuc and Phani Sista
Thesis Advisor: Dr. Alejandro Serrano
Introduction

Welcome to the 2011 Master of Engineering in Logistics and Supply Chain Management (ZLOG) Research Journal!

The seven papers included in this journal were chosen from the eighteen theses submitted by the ZLOG Class of 2011 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 for the business problem being addressed, the methods used to analyze the problem, 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. The topics include: Forecasting, Inventory, Packaging, S&OP, Procurement, Postponement, Finance & Supply Chain, Network Design, Supply Chain Integration, Global Health and Humanitarian Supply Chains. 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.

The projects highlighted in this journal reflect the variety of ZLOG student interests. Most of the 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 challenges, 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 want to access the entire thesis of any of those appearing in this journal, just let us know and we can make it available to you. Also, 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. Common labeling can provide significant benefits in the form of pooling to a pharmaceutical regional distribution hub
2. When utilizing a regional distribution hub in the pharma industry, airfreight typically lowers total relevant supply chain cost
3. When utilizing innovative financing mechanisms pharma companies should incentivize distributors to increase product availability

Introduction

Pharmaceutical companies have increased their focus on serving the African market for numerous reasons, such as the presence of new innovative financing programs, corporate social responsibility and aid programs, or because of an increase in wealth that enables more individuals to afford pharmaceutical drugs (Foster, June 1990). In order to compete successfully in a market such as Africa, pharmaceutical companies need to focus on lowering the cost and increasing the availability of their products. Within the pharmaceutical market supply chain, operations are greatly influenced by regulatory constraints. By determining the optimal way to operate its supply chain under various regulatory environments, the manufacturer can make smart long-term investment decisions and maximize profit in emerging African markets. The consumer can also benefit from receiving drugs at a lower end cost.

Methodology

The region of the East Africa Community (EAC) was chosen as the focus for the study due to the many potential future regulatory changes resulting from the formation of the EAC political, economic and customs union. The main regulatory cost drivers that were identified within EAC were:

1. Import Tariffs
2. Common Label Opportunities
3. Pharmaceutical Registration Harmonization

Import tariffs in the EAC have been eliminated for pharmaceutical products as of 2011, and pharmaceutical registration harmonization in the region is still quite uncertain and many years off. As a result, the analytical model developed focuses primarily on opportunities related to utilizing common
labeling. Common labeling can be used in regions such as EAC in order to reduce the number of SKU’s, where instead of one per country, one common labeled SKU is utilized for multiple countries within the region. Utilizing a common label allows the supply chain to obtain aggregation or pooling effects.

A likely trajectory of supply chain improvements was utilized in the model to show how a manufacturer could build upon different improvements to obtain the optimal operating environment. This trajectory is shown below.

Analytical Model

An interactive model was used where input variables can be tweaked by the user and the change in output can be seen graphically, with inputs and outputs seen in the table below:

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand data per country</td>
<td>Inventory</td>
</tr>
<tr>
<td>Shipping mode (Air, Ocean)</td>
<td>Cycle</td>
</tr>
<tr>
<td>The use of common Label (yes, no)</td>
<td>Pipeline</td>
</tr>
<tr>
<td>% Improvement in forecast</td>
<td>Safety</td>
</tr>
<tr>
<td>% Variability of mean demand</td>
<td>Lost Sales</td>
</tr>
<tr>
<td>Service level</td>
<td>Costs</td>
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<tr>
<td></td>
<td>Holding</td>
</tr>
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<td></td>
<td>Lost Profit</td>
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<td></td>
<td>Transportation</td>
</tr>
</tbody>
</table>

The optimal setting depends on the product attributes and ultimate goals determined by the user.

Three graphic interactive models were presented. In the first model, all inputs can be changed including demand inputs per country in East Africa, with outputs changing accordingly.

In the second and third models, a similar setting as in the first model was used without the ability to change demand inputs, but a comparison with respect to the base scenario (No common label & air transport) is provided as inputs change. With the comparison to the base model, users will immediately know if they are better or worse off as the change presented is a percentage change from the base model.

Results & Conclusions

As there are numerous scenarios that can be examined by users, a few select scenarios were chosen to show the effect on main supply chain metrics.

In the first scenario (Shipping Mode), it was apparent that the benefit from shipping by air outweighs the benefit from shipping by sea as more safety stock and holding cost will be incurred due the long lead-time involved.

In the second scenario (The Use of Common Label), it was apparent how common label creates savings due to the advantage of the pooling and aggregation effect where uncertainties are reduced.

In the third scenario (Product Life Cycle), it was shown that the overall supply chain costs and inventory levels will increase for new products as there are more uncertainties in demand. However, it was advised that some qualitative measures need to be taken in consideration when launching new products.

In the fourth and fifth scenarios (Service Level & Demand Variability), it was shown that the total supply chain cost increases as demand variability increases, as more uncertainties are created in the system. In regards to service level, as it increases, more costs will be incurred for holding more inventory. However, at one point it can be offset by reducing lost sales as profit increases, and it is easy to determine this point while performing sensitivity analyses while changing the inputs.

The graphs below illustrate the tradeoffs as service level and demand variability is changed.
Innovative Financing Program Introduction

There are many innovative financing opportunities available to pharmaceutical manufacturers in order to increase the reach of pharmaceutical products and reduce the cost to end consumers. As these programs such as Affordable Medicine Facilities-malaria (AMFm) or GAVI for vaccines become more prominent, pharmaceutical companies will need to understand how these programs impact their supply chain. Gaining a better understanding of these impacts will allow a pharmaceutical company to better take advantage of the financing programs.

AMFm Background

The table below shows on average how the 300,000 annual cases of malaria in Africa are treated, where the patient receives treatment, and what type of medicine is received (Yadav, 2010; The Economist, 2007). The goal of the AMFm program is to increase the availability of Artemisinan Combined Therapy (ACT) drugs. ACT’s have proven to be the most effective drug against malaria; also, in the long term, use of ACT’s will help prevent the development of resistance by the malaria carriers (The Global Fund).
When utilizing the innovative AMFm financing program, the program host (currently The Global Fund) provides payment directly to the manufacturer for approximately 95% of the PO value and the first-line buyer or distributor pays the remaining 5%.

The charts below illustrate the difference in price at each stage of the supply chain for malaria medication. As can be seen, on average the price is significantly reduced.

**ACT distribution without AMFm**

- **ACT Manufacturers**
  - Private Buyers Buy for $2 to $3
  - Retailers Buy for $5 to $8
  - Patients Buy for $6 to $10

- **Public Tenders Buy for $1**
  - Public Medical Providers Buy for $1.5
  - Patients Free

**ACT Distribution Utilizing AMFm Program**

- **ACT Manufacturers Get 95% of PO Value from AMFm**
  - Private Buyers Buy for $0.05
  - Retailers Buy for $0.25
  - Patients Buy for $0.5

- **Public Buyers Buy for $0.05**
  - Public Medical Providers Buy for $0.25
  - Patients Free

The significant difference in price between ACT’s utilizing AMFm and those not utilizing the program will lead to a competitive situation in which it will be extremely difficult to compete in an AMFm country without utilizing the program. The current market share held by manufacturers who are members of the program is shown below. Overall, generic drug manufacturers have been more successful utilizing the program to date than originators.

**Manufacturers' Market Share**

- **NOVARTIS** 21%
- **AJANTA OINS** 17%
- **CIPLA** 22%
- **GUILIN** 2%
- **IPCA** 32%

**AMFm Recommendations**

In general, utilizing a program such as AMFm will impact a manufacturer’s supply chain. There will be restrictions on utilizing only approved first-line buyers as well as receiving payment on the same purchase order from two different sources, amongst other impacts.

Based upon these supply chain impacts, our study has identified several key recommendations for a company utilizing the AMFm program.

1) Prepare for operational changes, mainly receiving payment from two different sources
2) Analyze opportunities for collaboration by changing standard supplier terms from letter of credit to open account
3) Understand the impact of public information and visibility causes on interactions with distributors and agents - all AMFm information is public
4) Work with wholesalers/ distributors who can ensure greater market penetration of ACTs to remote and rural areas
5) Ensure that ACTs are present in the appropriate retail outlets and that the proper set of wholesalers/distributors is being used to reach necessary retail outlets.
6) When marketing manufacturer-specific ACT medications in-country focus on product attributes as differentiators due to common AMFm logo marketing campaigns.

**Works Cited**


Yadav, P. (2010)
**Direct-to-Pharmacy Distribution in Spain: An operational and politico-economic analysis**

By Pedro Campos and Alvaro Galve

Thesis Advisor: Dr. Prashant Yadav

**Summary:**
The thesis attempts to design an operating strategy for a direct-to-pharmacy distribution model for healthcare/pharmaceutical products in Spain. Through a simple model it captures the benefits of a direct-to-pharmacy (D2P) model for manufacturers, healthcare system, retail pharmacies, and logistics service providers (LSPs). Additionally, it suggests ways to implement the model using nonmarket strategies that enable regulatory changes and stakeholder acceptance of a D2P distribution model.

**KEY INSIGHTS**

1. Applying nonmarket strategies may allow a LSP to create a sustainable direct-to-pharmacy distribution model.
2. Starting initially with D2P for generic pharmaceutical products may evoke a weaker counter-response from the incumbent wholesalers.
3. Using an options-based decision framework can allow the LSP to dynamically readjust its strategy and minimize its risk.
4. LSPs must be able to adapt to flexible and fast scalable operations to create a successful direct-to-pharmacy distribution model.

**Introduction**
The distribution of medicines around the world is organized in different ways depending on the country. The most common distribution is done by wholesalers, who are responsible for having a large number of medicines in stock. The activities performed by wholesalers can also vary from country to country.

Full-line wholesalers operate in Spain and most parts of the EU, and they carry a large range of pharmaceutical products from different companies. However, due to the large number of suppliers, it is economically difficult for wholesalers to organize import, warehousing, storage, distribution, and financial management for pharmaceutical manufacturers.

Thus, the role of Logistic Service Providers (LSPs) or pre-wholesalers emerges. The LSPs offer their services to manufacturers and to full-line wholesalers, thereby becoming the prolonged arm of the manufacturers, as they hold their stocks in consignment.

Full-line wholesalers offer to retail pharmacies a high frequency of deliveries and a short lead time, many times less than three hours. Pharmacies in general tend to have one main full-line supplier and two to three additional suppliers that are responsible for a smaller share of its volume of purchases. The objective of these additional wholesalers is to offer specialized products or to be used in case of stock-out situations.

The redesign of the prescription drugs supply chain in Spain can bring a more cost-efficient distribution...
model by reducing inefficiencies of the current distribution system and sharing the benefits among the complete supply chain. However, pharmaceutical distribution regulation needs to be adapted to allow more competitiveness in the prescription drugs industry, by using LSPs and the D2P distribution model.

Analysis of the current state

The validation of the regional industry competition model in Spain was based on the review of regulation, review of competition level (in terms of number of competitors and competition drivers), insights from interviews with LSPs, pharmaceutical companies, wholesalers, retail pharmacies, industry experts, and academic observers.

The current route to market of prescription drugs in Spain relies only 3% on the D2P channel while traditional wholesaler channels represent 76%.

When the complexity of the National Healthcare System (responsible for 85% of the reimbursement of prescription drugs) is added to the picture, a vicious loop emerges in the currently established combination of government healthcare reimbursement and regulation underlying the supply chain. This vicious loop makes it impossible for the supply chain to evolve to a D2P model without structural changes in the regulation and incentive schemes in the different echelons of the supply chain.

The healthcare system currently depends on the wholesalers for the distribution of medicines. The cost of the current traditional distribution model (6.5% of the total medicine expense in Spain) reflects the high service level offered to the retail pharmacies and the reimbursement policy that pays wholesalers a fixed percentage of the reference price of the medicine.

There is interdependence among delivery frequency, inventory levels, stock outs, operating cost of wholesalers, and the pressure on the government budget. As a consequence, the loop continuously increases the pressure for extending the payment terms to the pharmacies in order to balance the deficit in government accounts.

It is necessary to interrupt this vicious loop by using a “nonmarket” strategy to change the current regulation and create the possibility of a full implementation of D2P with the support of LSPs.

Solution Design

First, we carried out a nonmarket simulation using PolicyMaker® in which we calculated the best approach to implement a D2P policy. We found that a LSP should initially register as a wholesaler with the Medicine Agency and utilize a market entry strategy that minimizes reactions from existing wholesalers.

In this entry strategy, we selected generic pharmaceutical companies as partners for three reasons. First, generic price generates very low incentive to wholesalers to push it to the market, so currently, they are approaching pharmacies offering bargaining conditions and going direct to pharmacy. Second, according to the information we could gather in the early stages of the project, the pharmaceutical companies of generics will gain market share in the future. Finally, if a big pharmaceutical company introduces an LSP in the D2P market, it would most likely meet a strong reaction from wholesalers, who would feel...
Choosing a partner from the generics minimizes the probability of wholesalers’ reaction.

In order to answer these research questions, the methodology proposed was a Monte Carlo simulation aimed at investigating the potential savings in the Direct-to-Pharmacy distribution model when compared with the current traditional distribution model. To create a strategy to implement a D2P model, a PolicyMaker® simulation was used, considering the politico-economic forces involved in the subject.

**Conclusions**

Since current legislation is not favorable for D2P, the LSP should initially register as a wholesaler with the Medicines Agency and utilize a market entry strategy that minimizes the potential reaction from incumbent wholesalers.

In this entry strategy, we have selected the generic pharmaceutical companies as partners for three reasons. First, the low prices of generics generate very low margins for the wholesalers, and they have little incentive to push it to the market. So generic pharmaceutical manufacturers are going direct to pharmacy already by approaching retail pharmacies, and offering them better contractual terms.

Second, generic pharmaceutical companies are likely to gain market share in the future. If an LSP enters the D2P market by representing the products of a large pharmaceutical company, it will most likely evoke a strong reaction from incumbent wholesalers, who would feel threatened by such a move. History reminds us of the attempt of Pfizer trying to implement a D2P policy and failing to accomplish the goal due, in part, to the noise they made as new entrants.

The results of the operational simulation showed that the profitability of the LSP and the savings of the total supply chain are negatively correlated with the number of generic pharmaceutical companies that join the initiative. When the number of pharmaceutical companies increases, the profitability of the LSP also increases but the savings of the total supply chain decrease. One positive side of this negative correlation is that the LSP can adjust its entry strategy (including abandoning the D2P model, if necessary) generating the best information average of nonmarket strategy.

To be successful, two high-level capacities need to be developed: commercial capabilities and operational flexibility. These new sources of competitiveness can allow the LSP to operate in the new segment of D2P.

**Roadmap**

Conceptually, the option to enter in the D2P market to branded products in the future will be acquired by the application of the nonmarket strategy and by the operational learning acquired in the first five years of the project. Relevant changes in the internal processes are required.

A list of insights is provided, reflecting the key tasks that need to be implemented in order to construct the nonmarket capabilities (lobbying, marketing coordination, and business development) and to be able to reach the market opportunity of the D2P distribution model in Spain, enabling regulatory changes that favor the LSP in this new model. The figure below summarizes the five-year implementation roadmap designed to favor the success of the LSP in the future.
By Hugo Alfredo Castro Alvear  
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**Summary:**  
This thesis studies one possible solution for companies using agricultural by-products as supply. The dependency on agricultural farms to supply, the raw material needed for production create a huge planning challenge since agricultural products depend on nature creating volatility in the quantity and quality received. We review the concept of postponement and apply it to their business process and found an impressive decrease in inventory and a formidable improvement of 19% in fill rate.

**KEY INSIGHTS**

1. Dependency on agricultural farms to supply the raw material needed for production create a huge planning challenge.

2. In order to prevent stock outs when using agricultural by-products as supply, companies tend to increase their inventory.

3. Packaging postponement of such perishable products can reduce significantly the level of inventory and improve service level.

**Introduction**

Today’s competitive environment and increasing variation of consumer preferences is generating enormous challenges to meet those specific demands in a competitive manner. The proliferation of SKU’s (Stock Keeping Units) is furthermore fueling the implied uncertainty of demand and taking power from the supplier when it comes to deciding in what specific product and production process they want to specialize. The need to accommodate each demand requisite is continuously decreasing the ability, as a supplier, to operate in an efficient and effective manner.

In the agricultural by-products industry supply chain, customer specific requirements, mandatory quality as well as fierce competition create that these types of companies comply with every request increasing their number of SKU’s to an “infinite” number of options. Although in this industry, companies try to provide the best customer service not only to priority customers, but also to small mom and pop stores, they sometimes lack the ability of providing such a consistent service due to the fact that they do not control the availability of supply. This causes that in any given period of high supply availability companies try to build up inventory to guard themselves from the lack of supply that could possibly happen in the near future. This of course creates high levels of inventory produced based on a forecast that may be wrong leaving us with the wrong inventory at the wrong time.

In order to deal with this complex supply chain and complicated business model, this thesis examines the feasibility of the concept of postponement onto such supply chain. Specifically this thesis examines the viability of packaging postponement, where the by-product will be stored in bulk tanks as work-in-process waiting for the demand signal to be packed and finished.

First, we investigate and analyze the concept and applications of postponement in different industries as well as some real examples with actual results. Then we introduce Fruit International, the case...
company, where we performed the study. After that we execute some statistical analysis to understand the distribution of the supply. Subsequently we introduce our selection criterion corresponding to our SKU selection. Following we created a simulation model in ARENA software in order to replicate the current and postponed scenarios.

Industry Case

Fruit International is one of the world leading marketers of fresh fruits and vegetables. As a food conglomerate their name will always be linked to the banana’s long and successful history as a market leader in production and trade.

As a leading fresh products and fresh produce products manufacturer and trader they are divided into six main activities/departments: Whole Fruit, Bananas, Healthy Food, Processed by-products (PP), Shakes and Salads. With more than two hundred customers spread around the globe having in place an optimal, if not perfect, production plan is one of the main concerns of the company.

The thesis focus is on the Processed by-Products (PP) division. The division offers more than 250 fruit ingredients products in a very extensive variety of packaging types and sizes. Products ranging from frozen chunks, dried pieces, purees, concentrates, juices, extracts, essences, powders and flakes can be found in the manufacturing plants of the company.

The supply chain of these products can be quite extensive and complex. Its distribution can be made either directly to strategic customer or to company owned warehouses located in US or Europe. The constant dependency on agricultural farms to supply the raw material needed for production create a huge planning challenge as a problem in getting high quantity and quality of supply.

Production Process

The PP division is in charge of further processing “industrial fruits”, fruit that doesn’t meet the quality standards to be exported. We refer to quality standards not in terms of edibility, but in terms of shape, weight and appearance.

The industrial fruit is “created” every time farms are harvested. There are several fruits used by the division that range from (but are not limited to) banana, mango, pineapple, peach and watermelon. There is some seasonality in the production and availability of the fruits used. There are products that can only be made during certain seasons of the year. We will focus more on bananas since it is the best selling product as well as the fact that it is produced all year round.

Banana production is very volatile since it depends on many factors like weather temperature, amount of fertilizer applied, Sigatoka Negra (a banana disease) control, amount of water supplied to the plant, and many others. Since the quantity harvested of fruit is so volatile, accordingly this creates a very unstable and varying environment for the production of industrial banana.

The process starts at the farms. Every week the banana is harvested and industrial fruit is created. The process of picking this industrial fruit is, most of the times, made by truck drivers that will then sell the banana to manufacturing plants like Fruit International or to local informal markets.

When the fruit is processed for puree, the puree has to pass through several pipelines in which it is subject to very high temperatures that will sterilize the puree and eliminate any bacteria. At the end of these pipelines there is a filling section in which depending on the packing required by the order, the puree is then put into a vacuum-pack sterile bags. There are several packaging presentations of the puree, in pallets, in drums, in small sterile bags or with different special packaging features required by the order. These different combinations of packaging are available for the different combinations of the puree.

When the product is finished it is momentarily stored for at least five to seven days for observation. Given the nature of the product and the importance of a clean and secure process, packed puree must be monitored in case there were some bacteria’s left or the bag is not vacuum-packed containing oxygen that in the end will help in the process of bacteria creation.

These kinds of products are exported on a daily basis via container ships either to direct customers or to privately owned warehouses.

Postponement

In order to maximize the benefit of postponement it was important to perform an extensive study of the more than 250 SKU’s produced by the company.

We evaluated fruits and product families due to the nature of their manufacturing process and proliferation of packaging. We chose banana as a
fruit to focus on in our analyses. Although there are several products deriving from this fruit like flakes, chunks, extracts, frozen pieces, within this family of products the one that fitted best was the puree.

We will create a modular puree; a basic puree that needs small extra processing to create all other kinds of purees. It will permit a more efficient use of the facilities. We have three types of banana supply X, Y, Z we will have three bulk tanks that will store the modular purees corresponding to each raw banana type (organic, regular or rainforest alliance banana).

Purees X, Y, Z will be stored in the tanks in their more modular stage. Further processing will be needed to cope with special kinds of purees, but the company considered that this extra processing would take only a small amount of extra effort. Then again we will also postpone the packaging stage until demand realizes. This process means that we will have more work-in-process inventory but less finished goods inventory.

Simulation Model

ARENA software was chosen to perform the simulation of the current scenario and the new situation. By doing this we are going to be able to compare the current scenario (W/O postponement) with different postponement scenarios.

We choose to simulate 10 of the most selling products that represent almost 75% of the total volume sold during a period of two years. The macro level study gave us some operational results.

The complicated business model posed by the company push us to make several assumptions that, even when not able to completely represent reality, they somehow provide a good understanding of the current situation.

Results

We observed some of the following results. Please note that we didn’t focus on any cost effectiveness analysis but rather more a performance base study.

Scenario 1- Postponement Under Constant demand

The arrival rate and the volume required by each order were set as constant across the simulation.
Scenario 2 - Postponement Under Stochastic demand

The arrival rate (time between arrivals) of the orders from each SKU was set as random. The volume of each demand order stayed untouched and constant.

Inventory

Inventory level at the tank increased, but the total level of inventory was low, meaning again that the postponement strategy under demand randomness is still better than the current scenario.

From the literature we know that one of the major benefits of postponement may be present when the variation between customer orders across SKU’s is greater. This is what we tried to simulate in this scenario. The pooling of the variation of the demand is done under postponement meaning that the whole system bears less variation compared to the variation felt by the system in which we managed the SKU’s independently. This precise concept of pooling is what prevents us from producing the wrong inventory at the wrong time.

Fill Rate

We observe that we no longer have a stable service level across SKU’s. Demand variability as expected caused that we could not deliver the same level of service for every SKU. However even under some slight randomness in the demand average performance of postponement was better. In the model W/O postponement, the average “fill rate” was 64%, while in the model with postponement it was 70%.

We can observe the difference between the performances during random demand arrival rate (RND) and constant demand. As expected there was going to be some decrease in performance in both cases, but overall the postponement scenario continues to be better than the current situation.

Conclusions

In our research we have analyzed the benefits and drawbacks of applying postponement in an agriculture related industry. We have also studied the effects of the new strategy on key performance indicators.

Inventory is the most affected (positively) measurement when we applied postponement. We were able to demonstrate that inventory level of finished products will decrease significantly. On the hand there are some non quantified benefits of the reduction in inventory such as: risk pooling of demand, less risk of obsolesce, less risk of producing the wrong inventory, a decrease in holding cost, decrease in warehousing cost and some financial savings.

Fill Rate improved. We prove that with postponement we have a higher level of responsiveness with less inventory on hand.

Finally, variation in the demand arrival rate prove that it was not an excuse to not implement the new strategy since even with randomness the postponement scenario is better than the current one.
KEY INSIGHTS

1. In no case, a 100% quantity inflexible contract is the optimal way to procure platinum. A mix of ~60% quantity inflexible, ~20 quantity flexible and ~20 spot/financial hedging procurement is observed idea across scenarios.

2. Under production uncertainty, quantity flexible supply contract allows the firm to reduce inventory holding cost and total amount of platinum purchased.

3. Depending on the growth and volatility in the spot market, the expected profit/loss and its implied risk for financial hedging strategy varies.

Production uncertainty – There is strong correlation between vehicle demand and platinum price. This discourages automotive industry from making capital investment in platinum and keeping it for long-term.

Supply restriction – More than 75% of the platinum is mined in a single country, i.e., South Africa. Challenges such as industrial unrest and safety-related stoppages make it difficult for major mining companies in this region to increase their capacity in the foreseeable future.

This thesis studies the optimal procurement strategy under the price and production uncertainty. Many previous papers have focused on solving problems under the deterministic demand assumption or limited market access. But this study incorporates different types of supplier contracts, financial hedging strategies and spot market procurement. In order to measure the expected benefit or loss over baseline, from using a portfolio of strategies under various scenarios, the Monte Carlo simulation model was used. This mathematical framework will provide the automotive industry with a tool to analyze the benefit of having different supplier contracts.

Introduction
The recent dramatic increase in platinum prices has added substantial costs to the automobile industry. There are several challenging issues that add to the complexity in the hedging strategy for platinum.

Price volatility – High price volatility makes it difficult to use a financial hedging strategy.
conditions and hedging strategies over the planning horizon.

**Basic Assumptions and Simulation Framework**

This thesis looks at two types of supplier contracts – Quantity Inflexible Supplier Contract (QISC) and Quantity Flexible Supplier Contract (QFC). For QISC, the company receives a discount of 7% over the spot price but is forced to buy a fixed quantity every month, irrespective of the vehicle demand. For QFC, the company receives a discount of 4% over the spot price but can buy 20% lower (LL) or 20% higher (UL) than the quantity every month.

The volumes contracted by QISC and QFC are based on the company’s market expectation of platinum demand for automotive production for the next 5 years.

The spot market is assumed to be always available and the model also assumes that the spot market is insensitive to the company’s market intervention.

Baseline contract is assumed to be a 100% QISC (100% of market expected platinum demand) at a 7% discount over spot price and spot market is always available.

The simulation model needs a set of inputs – policy inputs (specifics of the contract), engineering inputs (average platinum per vehicle) and historic information on vehicle production and platinum prices – in order to simulate the scenarios.

The simulation model has the flexibility to change all these values. Spot market availability can be turned on/off or can be made available 50% of the time.

The simulation model looks at a 5-year planning horizon and each simulation run is 500 iterations. All the results mentioned below are on an expected basis.

**Portfolio of Strategies with Supplier Contracts**

In this thesis, several scenarios were analyzed and costs of a portfolio of strategies approach a baseline contract were compared. The scenarios that were looked into were different variabilities in vehicle demand and spot price (0.01%, 20%, 40%, 50%, 80%, 100%, 120%, 150%), a actual market trend (2006-2010 historic trend, positive 8% growth year on year, negative 8% growth year on year), market expectation (positive 8% growth and negative 8% growth year on year), selling of excess inventory (at the end of every year, at the end of 5 years) at a 15% penalty over the price (spot price, 12 month average price).

The thesis also looked at the minimum discount QFC should offer for a given set of input conditions to make it worthwhile for the company to use QFC in the portfolio.

**Results**

Under each of these scenarios, the simulation model varied QISC and QFC from 0% to 100% and the benefits over baseline is populated into a table as in Figure 1.

The shading is relative to the benefits and the lowest benefit is red (bottom right corner) and the highest benefit is green (diagonally from bottom left to top right). The colors transition from red to green via yellow (lighter shade). In Figure 1, the right bottom corner is in red and the top left corner is in yellow. In the middle, where there was a higher benefit, a green was given.

In Figure 1, the effect of actual market trend on the over benefit of portfolio of strategies under a low variability of 50% is depicted. In the first table (Scenario 1), when the actual market trend was similar to the 2006-10 trend, results show that ~70% QISC and ~20% QFC is an optimal mix, leaving 10% for the spot market or for a financial hedging strategy. In the second table (Scenario 2), when market expectation was bang on the money, the results show that ~90% QISC and the rest in spot market or financial hedging is an optimum way of platinum procurement. In the last table (Scenario 3), when the actual market trend is opposite the market expectation, the model proposes to use less of QISC (~40%), more of QFC (~30%) and leave the rest for the spot market or financial hedging.

**Figure 1: Scenario analysis for QISC and QFC**

Based on the company’s decision of when to sell the excess inventory, benefit of portfolio of strategies vary as shown in Figure 2. If excess inventory is sold at the end of every year, benefit of portfolio is
strategies is in the range of ~4% and if the excess inventory is sold once every 5 years, the benefit is in the range of ~20%.

For various reasons, it might not be feasible to sell the excess inventory at the end of every year or can only happen with heavy losses. The company might want to wait for a favorable time. Hence the likely benefit of portfolio of strategies, intuitively speaking, should lie in the shaded region in Figure 2. Also what can be observed is that the benefit decreases at a faster pace when Q ISC is over 50% in this scenario considered.

In order to test the robustness of using ~20% QFC for platinum procurement, the performance of 20% QFC under 9 different scenarios – that varied in market trend (historical, positive, negative) and variability (low, neutral, high) – were analyzed. As can be seen in Figure 3, the best portfolio of strategies was found to be in the QFC 20% to 30% region, irrespective of the scenarios. Figure 3 uses a 50% QISC. This was verified for other values of QISC as well.

Since the outcome of financial hedging strategies is very sensitive to the spot price movement, the above 5 scenarios were analyzed against 4 different spot price scenarios. The 4 spot price scenarios were historical trend, upward trend, static movement and slight downward trend. Since the platinum price is not expected to go down in the near future, the dramatic downwards trend were excluded from the analysis. The trends were controlled by parameters in the geometric Brownian motion. For each case a simulation of 500 iterations were run.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
<th>Mu</th>
<th>Sigma</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Historical Spot &amp; Futures Price</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Upwards Trend (based on historical trend)</td>
<td>0.0103</td>
<td>0.642</td>
</tr>
<tr>
<td>3</td>
<td>Static Movement</td>
<td>0.002</td>
<td>0.04</td>
</tr>
<tr>
<td>4</td>
<td>Slight Downwards Trend</td>
<td>-0.001</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Results

Under historical spot price scenario, the model showed that the firm could have potentially saved about 3% of the total platinum procurement cost, had the firm used one of the first two futures hedging strategies.
Our simulation results show that futures strategies are generally more beneficial than option strategies especially in the growing price environment. This is because of the up-front cost the firm has to pay when it buys the call option. Also by incorporating maximum loss limit policy, together with a futures contract, the firm can reduce the risk of incurring huge losses from procurement of platinum at the time of a black swan event.

**Conclusion**

The thesis started with the belief that there was a set of strategies that, if used in a certain manner, could procure Platinum Group Metals at the optimal cost. This thesis introduced a type of flexibility contract and looked at a combination of inflexible contracts, flexible contracts, financial hedging and spot market procurement.

One of the main conclusions of the thesis is that 100% inflexible contract is not the optimal way to procure platinum. Based on many different scenarios analyzed, an inflexible contract in the 40%~60% range and a flexible contract in the 20%~30% range is found to be a robust mix of supplier contracts. The remaining platinum of 10%~40% is bought using financial hedging strategies or in the spot market. This can be visualized in Figure 5. The benefit of introducing the portfolio approach ranges between 4% and 25% for all the scenarios analyzed, except for the scenarios where market expectation was bang on the money.

Financial hedging strategies entail a different type of risk, meaning it reduces the variance of the portfolio but it is still exposed to the potential loss of money from the transaction. Therefore, depending on the company's risk-taking behavior, it can be actively utilized or avoided. Considering the dramatic price increase in the market, it is attractive in that it can effectively reduce the upside risk and curtail the overall procurement risks. By incorporating the maximum loss allowance the company can avoid a huge loss in case of a Black Swan event.

The benefit of using a portfolio of strategies varies significantly based on the decision of when the excess inventory is sold, value of upper and lower flexibility in QFC, discounts in QFC and uncertainty surrounding the market expectation for the next 5 years. The benefit of introducing flexible contracts is minimal if the economy is inline with market expectation. The use of a flexible contract reduces the procurement cost of platinum when facing a Black Swan type of an event.

It can also be safely assumed that the potential benefit of using a portfolio of strategies along with financial hedging will be higher as the benefits from this simulation model are clouded by the strong assumption made by the spot market reaction to the company's intervention.
KEY INSIGHTS

1. Looking at the trade-off between logistics and packaging material costs and revenues is necessary for making balanced decisions.

2. Not all package size changes have an equal effect on sales and truckload efficiency.

3. Package changes can lead to shelf visibility increases while also decreasing costs.

Introduction

Today the concept of truckload efficiency is important to both companies transporting goods and society as a whole. Companies try to manage costs by increasing truckload efficiency, and society feels the effects of overcrowded roadways and pollution from transportation. Within Europe there is substantial area for improvement, since transportation vehicles have an overall load efficiency of only 43%.

There are many ways to address the problem of truckload efficiency, including analyzing factors like routing of vehicles, vehicle types, co-shipment opportunities, cube-fill utilization, product packaging design, or formula composition. The last two options for analysis represent a new way of looking at truckloads. Instead of analyzing the vehicles or how they deliver the products, the focus is on what is inside of the shipments on these trucks.

This thesis analyzes the impact that changes to product packaging and product formula can have on truckload efficiency and the entire supply chain within the fast moving consumer goods industry (FMCG).

The FMCG industry is a highly competitive industry, where marketing and brand image play a crucial role. Therefore, the marketing departments have an active responsibility in product packaging design. Their decisions are based on ensuring that products will sell and revenues will not suffer due to “bad” packaging. In contrast, logistics departments, concerned with the actual transportation of these goods and how they can be loaded into trucks for
transport, value creating packages that will lead to high truckload efficiency.

Thus, in order to facilitate changes to packaging, logistics departments must be able to demonstrate that product demand and profits will not suffer, i n spite of the changes. This creates a roadblock and the need for a new manner of expressing the effects of changes.

**Approach**

The approach to the research began by better understanding the work that had already been completed to measure and increase truckload efficiency. It quickly became apparent that much research had already been completed on this topic, and in hopes of providing insights, we focused on understanding how product packaging changes could improve truckload efficiency. To explain our new approach, we developed a theoretical framework and an Excel based tool and calculator.

**Framework**

Considering all that was learned regarding truckload efficiency and the need to create a new framework for addressing ways to improve truckload efficiency, we created a model that looks at packaging in terms of the entire supply chain. The model illustrates how changes in package size indirectly affect sales, by directly affecting logistics costs, price margins, service levels, and the product's carbon footprint. The framework is shown in Figure 1.

To understand the framework, it is important to explain the different relationships that are included in the three branches.

1. The first branch of the framework proposes that as product package size decreases, truck volume fill will increase, as products are smaller and more can be transported in the same space. Therefore, logistics costs will decrease, as fewer trucks are needed in transportation. Now that manufacturers have achieved savings in their logistics costs, they will share some of these savings with their retailers. Through a reduction in price to the retailers, without an increase in the price to consumers, the manufacturer allows retailers to have a higher gross margin on their product. The increase in gross margin for the retailer will then impact the product placement decisions. Retailers will be encouraged to place the product in a location that will be more visible and allow them to sell the new, more profitable product. As visibility increases, sales should also increase.

2. The second branch explains how the changes in product package size will affect the retailer's inventory stocking decisions. The lower price to retailers will allow them to purchase larger quantities of the product, which will lead to a higher availability of the product in the store. Consequently, the increased margin of the product will also encourage the retailer to improve their service level for the product so that they can avoid stock-outs of the new more profitable product.

![Figure 1 - Proposed framework](image-url)
3. The last branch of the model relates to the environmental impacts of packaging reductions. Through the reduced size of the package, fewer trucks will be needed to ship the same amount of products. This reduction in trucks will lead to a reduced amount of emissions from trucks used in transportation. The package itself will also need fewer raw materials, due to the smaller size. The positive effects that the manufacturer is having on society will be illustrated to consumers to show that the company is environmentally conscious. For the number of consumers whose purchasing decisions are influenced by environmental factors, this change should be positive and encourage them to purchase this smaller more environmentally-friendly package.

Excel Tool & Calculator

Building on our framework regarding the product packaging's relationship to the entire product supply chain, we developed an Excel-based tool. The tool allows a manufacturer to estimate the impact of changes in packaging and/or formula design.

The outputs of the tool show changes in consumer demand, gross profits (revenues minus transportation and packaging material costs) for the manufacturer, truckload efficiency for transporting the product, and retailer shelf visibility for the product.

The changes in consumer demand are calculated from the hypothesis that larger package size leads to better consumer perception and that more sustainable packaging makes products more attractive to environmentally conscious consumers.

Gross profits are determined by the estimated revenue for the product, minus the transportation and packaging material costs. The changes in gross profits are then calculated by the differences for the current and proposed products.

In order to illustrate the changes in truckload efficiency, the tool measures the difference in what percentage of the transport unit (truck) is product, packing material, and air, between the current and proposed product.

Lastly, the retailer's shelf visibility is calculated by the change in how many products can be placed on the retailer's shelf and how much of the shelf space is used by the product.

Application and Analysis

After completing our Excel tool, we tested various scenarios, where we made changes to product packages, for two types of products, a liquid fabric softener in a plastic bottle and a powder laundry detergent in a cardboard box. The different scenarios included changes to the package dimensions and product formula, in order to see the effects that these changes would have on demand and gross profits for the manufacturer.

In order to explain our key insights, we will explain one of the scenarios we studied, which analyzed the impact on logistics and packaging costs, demand, and profits, of changing the dimensions of the liquid fabric softener bottle. In the scenario, the product's formula was modified so that non-value adding water was removed and the bottle's height was increased and depth was reduced. These two changes would allow for a smaller size which would increase truckload efficiency for transporting the product and increase the shelf visibility of the product.

The impact of these changes shows how the manufacturer would benefit from reducing logistics and packaging costs, increasing demand, and profits, of changing the dimensions of the liquid fabric softener bottle. The complete results from this scenario are shown in Figures 2 and 3.

Logistics and packaging costs would decrease due to the increased truckload efficiency, the need for fewer trucks to transport the same amount of products, and the package requiring fewer raw materials for production, respectively. Profits would increase due to the lower costs and the increased demand for eco-conscious consumers who value environmentally-friendly products and would then purchase this product.

Figure 2 - Change in sales and cost structure
On the retailer's shelf, the product would then be more visible as the height of the product has increased to fully utilize all of the shelf's space. Additionally, now that the product has a smaller depth, more products will be able to fit on the same space on the shelf. This increase in products on the shelf will lead to a greater number of products on the retailer's shelf, instead of in storage in a stockroom. The increase in availability on the shelf should reduce the amount of stock-outs and lead to higher sales.

![Changes in shelf visibility](image)

**Figure 3 - Changes in shelf visibility**

**Conclusion**

The initial scope of our research involved analyzing methods for improving truckload efficiency. As we began our research of the topic, it became apparent that extensive research had been completed by companies within the FMCG industry in order to improve truckload efficiency, through studying methods of loading trucks, various truck types, and routing of vehicles. This created the opportunity for us to look at this topic from a new vantage point that could change how the topic had been addressed in the past. Thus, our research analyzes how changes to product packaging affect not only truckload efficiency, but the entire supply chain within the FMCG industry.

Through our work we intended to show the impact that changes to product packaging could have on logistics costs, retailer inventory decisions, and consumer demand. In order to demonstrate these relationships, we created a theoretical framework and an Excel tool and calculator. The framework illustrates the variables in the supply chain that are affected by product changes, and the Excel calculator can be used as a decision-making tool when considering packaging or product design changes. The purpose of this tool is not to reach 100% accuracy but to facilitate a balanced decision by providing a look at different trade-offs and to estimate potential benefits before going into further details.

In a large company, managers are required to make decisions before they have complete information or access to all relevant data. Different departments and functions often have competing goals and incentives, biasing their decisions. We envision our work as assisting companies within the FMCG industry to look at packaging design problems so that no key driver is forgotten and no factor is given excess attention. We expect that various aspects of the model may face some criticism, but nevertheless, see it as a benefit for stimulating discussion.
Supply Chain Integration and Customer Relationship Orientation

By: Chris McDuling
Thesis Advisor: Prof. Dr. María Jesús Saénz

Summary:
This thesis confronts the challenging topic of inter-organizational learning from and together with customers and the elements of successful customer integration. Through survey-based research, it was found that trust and alignment are key elements to enhance customer integration, which further impacts the learning cycle of exploration, assimilation, and exploitation.

KEY INSIGHTS
1. The capability to learn from and with customers in a trusting relationship has a significant impact on perceived customer performance
2. Learning with customers is positively impacted when the relationship is aligned and integrated, even more so with unpredictable market conditions

Introduction

“One of the most significant paradigm shifts of modern business management is that individual businesses no longer compete as solely autonomous entities, but rather as supply chains”. “In this emerging competitive environment, the ultimate success of the single business will depend on management's ability to integrate the company's intricate network of business relationships” (Lambert & Cooper, 2000).

Integrating the network of relationships in an environment of an increasing number of decision makers and complex, interdependent markets is a massive challenge. This requires organizations in supply chains to continuously grow their capability to jointly learn about their customers and design supply chains that can meet and exceed those requirements. “This then is the basic meaning of a “learning or ganization” – an organization that is continually expanding its capacity to create its future.” (Senge, 1990)

Although these topics have been the focus of past research, many factors have prevented successful initiatives such as functional silos, short-term financial thinking, lack of common IT architecture, defensive reasoning and a poor understanding of what organizational learning actually is.

The goal of this research was to answer the following questions:
1. What are the key elements of successful customer-facing supply chain integration?
2. What are the expected effects of inter- and intra-organizational learning in a customer-facing supply chain relationship?
Approach

This research is a continuation of past research by Gradin and Jansson (2010), which focused on inter-organizational learning with suppliers. The company that was studied is the logistics division of a major manufacturer in the heavy machinery industry. In order to complete the supply chain perspective on inter-organizational learning, almost 200 independent dealers across six continents were analyzed using survey research. Dealers are both 1st tier customers and sales- and service agents interfacing with end-customers.

After testing the reliability for the data, hierarchical multiple regression as well as cluster analysis was used to test the statistical relationship between the different constructs and performance. Perceived performance was broken down into efficiency, improvement, agility and innovation, to test how inter-organizational learning might affect each one differently (Figure 3). The model explained the impact on all the perceived performance outcomes, with the exception of innovation. This might be due to the fact that innovation is focused internally on product research and development, and not on innovating supply chain processes. This is an area with substantial strategic potential, since it indicates that supply chain innovation is not yet well understood. Unfortunately, the relationship with actual performance was not statistically reliable.

Figure 3: Impact on Perceived Performance

After developing the theoretical framework, data was gathered about the dealers’ perception on the various constructs and performance. The initial number of responses received was 215 from a distribution list of approximately 500 (43% response rate). Of the 215, a total of 134 responses were fully completed (62%). The majority of respondents were highly experienced and from North and South America. Additional KPI data for 2010 was obtained for each dealer to be used as actual performance data.

After testing the reliability for the data, hierarchical multiple regression as well as cluster analysis was used to test the statistical relationship between the different constructs and performance. Perceived performance was broken down into efficiency, improvement, agility and innovation, to test how inter-organizational learning might affect each one differently (Figure 3). The model explained the impact on all the perceived performance outcomes, with the exception of innovation. This might be due to the fact that innovation is focused internally on product research and development, and not on innovating supply chain processes. This is an area with substantial strategic potential, since it indicates that supply chain innovation is not yet well understood. Unfortunately, the relationship with actual performance was not statistically reliable.

Figure 4: Impact on Absorptive Capacity and Customer Integration
Results

The results confirmed most of the hypotheses and found additional insights with regards to the relationship between customer integration and absorptive capacity as well as the different performance measures. These findings were summarized in order to facilitate application and further development (Figure 5).

Figure 5: Practical Framework

Trust

It all starts with trust. Trust is an antecedent of both customer integration and perceived performance; it can be viewed as both a facilitator and a mechanism to sustain the process. It facilitates integration in the sense of making information and knowledge available to trusted supply chain partners, and enhancing the probability of shared investments. Trust as a mechanism sustains the relationship when making joint decisions, with partners knowing that the desired outcome is mutually beneficial. Building and maintaining trust does not happen overnight and requires both parties to actively and vigilantly maintain an open and frank relationship. Keeping promises, not misusing sensitive information, as well as sharing any potential bad news without fear of damaging the relationship is important.

Alignment

Before integrating information or starting the learning process, it is important to select the right partners. Sharing the same goals, beliefs and mechanisms can smoothen the process of integration and prevent conflicts of interest, which can hinder all the learning cycle.

Customer Integration

There is no one correct way to develop a collaborative relationship. Sharing long-term goals and an unpredictable environment can be reasons to increase integration. With regards to learning from customers, frequent socio-technical interactions, joint planning and sharing of resources can enhance learning. Participation in collaborative projects can be open to encourage a wide range of ideas or closed for a focused approach. Governance can be flat when sharing risks and rewards is important, or hierarchical when not.

Absorptive Capacity

To continuously thrive, not only survive in a complex and interdependent world, requires the shared capability to learn from and with customers. Once a trusting partnership has been formed between aligned entities (individuals, teams, or organizations), absorptive capacity can be developed and grown through the continuous process of exploration, assimilation and exploitation. Critical elements of this process are feedback, simulation or low-cost experimentation, productive reasoning, as well as understanding the current situation and how systems, delays and policies affect it.

Continuous Process

Inter-organizational learning is a never-ending process and frequent reviews of successes and failures must be fed back to other levels of the organization and supply chain. Similarly, as drivers for integration change with market conditions, the level of integration should be reviewed.

Conclusion

This research uncovered valuable insights with regards to the benefits of integrated, customer-facing learning. Using these insights for customer-focused supply chain innovation has substantial potential for enhanced and continuously evolving strategic positioning.
Introduction

Most organizations have two planning processes that run concurrently within their firm. On the one hand, they have a demand planning process that estimates the number of units of each product they would sell during the planning period. On the other hand, they have a financial forecasting process that estimates the revenues they would make during the same planning period. Ideally, these two processes should be integrated, given the strong relationship between their outputs, i.e., the revenues made by an organization in a given period are a function of the units sold by them. In reality, these processes are executed in silos and their outputs, more often than not, do not agree with each other.

In this thesis we explore ways by which the process of financial forecasting may be linked to the demand planning process by deriving the financial forecast from the volume based demand forecast, thereby creating operational and financial plans that are realistic, achievable and in synchronization with each other and the overall business goals of the firm.

Business Scenarios

In order to formulate a basis for the analysis, we have identified different ways in which the sponsor organization sells goods or services to its customers. These business scenarios, describe the majority of the company’s business and the complexity
associated with each of these distinct forms of business transactions arises from changes: in who the customer is (internal or external), the price applied to the transaction (contract, spot or transfer), the currency in which the transaction is carried out, the discount and payment terms offered on the transaction.

**Forecasting Variables**

Further, in the context of the identified business scenarios, we classify all the variables that impact a financial forecast into two major categories: Modeling variables and Integration variables.

The variables can impact BUFF in one of two ways:

1. By affecting the calculation of the financial forecast from the demand forecast. All such variables are referred to as modeling variables.

2. By introducing a dependency between the bottom-up financial forecasting process and demand forecasting process. All such variables are referred to as integration variables.

**Modeling Variables**

Modeling variables directly affect the calculation of the financial forecast. The identified modeling variables are Price, Customer, Currency, Discount and Collection Period.

We studied each modeling variable to understand the issues it raises vis-à-vis BUFF. For example:

**Price** - A key insight here is, trying to achieve greater precision in financial forecasting by applying the relevant price to a given bucket of demand entails the risk of losing precision in the demand forecast at lower levels of aggregation. The idea is to find an appropriate balance of the precision gained by using the right price and the precision lost in forecasting at lower levels of aggregation.

**Integration Variables**

Integration variables affect the execution of the bottom-up financial forecasting process by introducing a dependency between BUFF and demand forecasting process. These dependencies need to be addressed for BUFF to be executed successfully. The identified integration variables are Forecast Quantity, Forecast Level, Forecast Frequency, Actual Sales and Planning Calendar.

Here are a few insights we have developed based on the integration variable analysis:

**Forecast Quantity** - if an organization uses a rolling forecast process, where the demand forecast for a given month is frozen ahead of the month, a constrained forecast is always available as an input for the bottom-up financial forecasting process. However, if the organization is flexible enough to revise its demand plan for the current month because of business factors like volatile demand fluctuations, then a dependency between the planning calendars of both processes may arise. Such situations, however, are an exception rather than the rule.

**Process Design Considerations**

We further highlight the various issues thrown up by each of the forecast variables vis-à-vis setting up a bottom-up financial forecasting process. These issues need to be addressed satisfactorily for BUFF to be efficient and effective.

An example of design considerations we have identified can be represented by the analysis of Price.

Using demand forecast quantities at an stock keeping unit (SKU) level will result in a significant loss of precision vis-à-vis forecast accuracy, which will impact the overall accuracy of the BUFF. On the other hand, performing financial forecasting at a higher level of aggregation will also impact the accuracy of the financial forecast because of the inability to apply the most accurate price to a specific bucket of demand. One way of approaching this problem is to forecast revenues at the level where demand differences vis-à-vis customer / country group begin to emerge. Once revenues are calculated at the product line level, using a planned price for that level, they could be allocated to lower levels of product aggregation by the proportion of original sales forecasts (or other possible rules).

**Process Flows**

The general design of the BUFF, applied to any scenario, consists of four major phases: Plan, Prepare, Perform, and Monitor. There are five major tasks to be done: Define Financial Forecast Strategy, Gather Demand / Pricing / Other Data, Run Financial Forecast, Validate Financial Forecast, Manage Forecast Performance. This process design is effective and straightforward, and therefore can be applied at any organization that embarks on the mission of creating a BUFF process.
Based on the generic process flow structure presented above, further is an example of the detailed process flow design analysis we have developed for the first scenario, where the organization has a manufacturing facility in Europe that sells goods to internal customer (another business unit) within the same legal entity.

Plan Stage

The objective of this scenario is to demonstrate a bottom-up financial forecasting process for an “intra-company transfer of goods”. The steps within this stage are as follows:

- Define forecast objective
- Define target forecast accuracy
- Define forecast level
- Define forecast frequency
- Establish planning calendar

Prepare Stage

The steps executed during this stage of the BUFF process are as follows:

- Demand forecast data, broken down by necessary criteria, has to be identified by the BUFF process within a source-of-truth database and subsequently extracted for further use.
- Actual internal transfers that have occurred have to be extracted from source-of-truth database.
- Transfer pricing data has to be entered from the source-of-truth database maintained by the organization.

Execute Stage

The steps during this stage are as follows:

1. Run Financial Forecast
   - Apply the right transfer price based on the data from company rule-book database.
   - Generate projected revenues.
   - Generate projected revenue collection by applying different collection periods to buckets split by customer type.
2. Validate Forecast
   - Validate the forecast and communicate it to relevant stakeholders within the organization in a format most appropriate for the forecast objective.

Monitor Stage

The forecast performance should be compared to desired accuracy. Certain statistical and simulation tools can be used within the BUFF to shed light on the magnitude of uncertainty of the final result as well as point out the sources of this uncertainty among the underlying variables.

Reconciliation

To be able to perform the reconciliation between the operational and financial plans, the planners from the respective functions need to translate their plans into a common unit to ensure an “apples-to-apples” comparison. For example, either the operational plan which was originally in units needs to be translated to monies or the financial plan which was originally in monies needs to be converted into units. BUFF allows the operational plan to be restated in monetary value.

With BUFF in place, the reconciliation process must do the following:

- Place the forecast figures from BUFF and the financial plan side by side and observe the differences.
- Implement a strategy to deal with the difference. The way to reconcile the difference could be to:
  a) Modify the financial plan or the operational to reduce the difference to zero.
  b) Ensure that the difference is tracked across planning periods and is reduced to zero by modifying one of or both the plans.

Conclusions

In our opinion, Bottom-Up Financial Forecasting cannot replace Top-Down Financial Forecasting as the sole method to forecast revenues at the firm / business unit level. This is because Top-Down financial forecasting delivers the highest degree of accuracy for projected revenues at a firm level. It may be the best available approach to predict a firm’s financial performance in a given period and issue guidance to stakeholders accordingly.

Bottom-up Financial Forecast however, can be a remarkably useful tool for looking at the differences between actual and targeted figures at lower levels, subsequently being more accurate in identifying the causes for the differences.
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Portfolio of Strategies for Optimal Procurement of Platinum Group Metals (PGM) in the Automotive Industry,
By Leo Tom Zachariah and Jihwang Chang

This thesis studies the optimal procurement strategy for platinum under the price and production uncertainty. Different types of supplier contracts, financial hedging strategies and spot market procurement constitute the portfolio of strategies. This project developed a Monte Carlo simulation model to analyze the benefits of using a portfolio of strategies over the baseline under various scenarios.

Innovative Distribution Channels for the Pharmaceutical Industry in Europe: Analysis and first assessment of different Home Care & Home Delivery models,
By Lucas Chiang and Gustavo Rodriguez

This thesis addresses some of the challenges faced by the pharmaceutical industry in Europe by analyzing innovative distribution models that allow pharmaceutical companies to expand their focus from purely product focused to more service-oriented. Home Care and Home Delivery are feasible routes to market for producers to explore, and the analysis shows that such a strategy has the potential to increase the pharmaceutical companies profit and also improve the healthcare of all within the EU.

Online Logistics System (OLS) for the Copper Concentrate Mining Industry,
By Patricio Olivares and Ricardo Espinoza Condemarín

This thesis addresses the question of the value of the information that an Online Logistics System (OLS) can provide to the copper concentrate mining industry. In order to quantify the benefits generated by the system, a simulation model was developed and two scenarios were assessed, one with and the other without the OLS. The main benefits for the smelter companies were evaluated once the information flow was centralized and available in real-time.

Improvement of an Existing Sales & Operations Planning Process,
By Javier Flores Cortés

This thesis investigates the management approaches and process characteristics that allow cross-functional integration for supply chain planning activities. Different frameworks are used to propose a process that aims to coordinate the information flow and problem solving requirements of aligning supply and demand and allow cross-functional integration despite of incentives misalignments of different areas inside a company.

Improving the Sourcing Strategy for a Humanitarian Organization,
By Nikolina Galanova and Daniela Restrepo

This thesis focuses on how sourcing strategy affects the success of a relief operation during the first 48 to 72 hours in the aftermath of a disaster. The suggested sourcing model is built upon implementations adopted by other aid agencies and by a thorough analysis and improvement opportunities of their current processes and flows.
Packaging Design's Impact on Sales and Supply Chain in the Consumer Goods Industry,
By Daniel Gross and Sergey Parfenov

This thesis created a new framework for addressing the impact of product packaging and product formula design on truckload efficiency and the entire supply chain within the consumer goods industry. This project also developed a tool for estimating changes to consumer demand and gross profits, due to packaging and formula modifications.

Modeling an Efficient Planning Methodology in Pharmaceutical Supply Chain,
By Susan E Hanson and Yunan He

This thesis investigates how to reduce manual efforts in schedule and production planning without affecting planning accuracy by developing an efficient methodology. The planning process of a pharmaceutical company is analyzed by identifying qualitative exceptions and quantifying risk measurement. A simulation model is designed to compare the differences in labor time and inventory control between the current and new planning processes.

Supply Chain Integration and Customer Relationship Orientation,
By Chris McDuling

This thesis confronts the challenging topic of inter-organizational learning from and together with customers and the elements of successful customer integration. Through survey-based research, it was found that trust and alignment are key elements to enhance customer integration, which further impacts the learning cycle of exploration, assimilation, and exploitation.

A Decision Framework for Setting an Effective Stock Policy at MedOrg Supply,
By Arturo Jay Pua

The need to have the right products in inventory is a prerequisite for the realization of a truly effective stock policy. As such, this thesis labored to build this foundation for MedOrg Supply, an organization that supplies medical and logistics products to humanitarian field operations. The endeavor fundamentally devoted itself to designing and developing a tool that would guide MedOrg Supply in identifying the right products to stock and how these products are to be managed. At the same time, the project developed a procedure for determining the needed safety stock when constrained by the non-normality of demand distribution.

A Comparative Analysis of In-Market Pharmaceutical Distribution Channel Strategies in Sub-Saharan Africa: A Case Study of Kenya,
By James Mwenda Riungu

This thesis tackles the question of what is the right distribution channel strategy that a big pharmaceutical company can use to improve access to its medicines in the sub-Saharan African market in light of the risks and challenges inherent in the region. We analyze the existing distribution channel options, the risks associated with each one of them and explore possible strategies to mitigate the risks.

Linking Financial Planning to Demand Planning,
By Pavel Volosciuc and Phani Sista

In this thesis, we identify and analyze the variables that impact bottom-up financial forecasting using volume forecast, both from a modeling standpoint, calculating revenues using demand forecast quantities, and an integration standpoint, aligning the planning calendars of the demand forecast and financial forecast processes. We use the insights, gained from the analysis, to make appropriate recommendations for setting up a bottom-up financial forecasting business process and for monitoring its performance. Finally, as a logical extension to the ideas presented in this thesis, we recommend ways in which the bottom-up financial forecast may be used as the basis for reconciling the financial and operational plans within an organization.
ZARAGOZA LOGISTICS CENTER

Zaragoza Logistics Center (ZLC) is a research institute established by the Government of Aragon in Spain in partnership with the Massachusetts Institute of Technology (MIT) and the University of Zaragoza. Founded in 2003, the ZLC campus is located in the heart of PLAZA, the largest logistics park in Europe that serves as a working laboratory to transfer new knowledge and working practices. ZLC has rapidly become recognized as an international center of excellence for education and research in logistics and supply chain management focusing on:

- enhancing economic growth and competitiveness through innovation
- engaging with both industry and the public sector in the development and dissemination of knowledge

To accomplish its mission ZLC partnered with the MIT Center for Transportation and Logistics to form the MIT-Zaragoza International Logistics Program, a unique model of collaboration between industry, government and academia. This successful partnership led to the creation of the MIT Global SCALE Network that now spans four continents. In addition, Zaragoza Logistics Center participates in several national and international research and educational initiatives.

In 2008 the Spanish Ministry of Education and Science officially recognized ZLC as a Knowledge Transfer Office (KTO) after previously being designated the National Center of Excellence for research in the area of logistics and supply chain management, CNC LOGISTICA, in 2006. This latest recognition puts ZLC in the leading role to define and coordinate research, development and innovation initiatives across Spain in logistics and supply chain management.

ZLC has the continued support of local saving banks Ibercaja and CAI and the European Social Fund in its activities.

MIT ZARAGOZA INTERNATIONAL LOGISTICS PROGRAM

The MIT Zaragoza Program encompasses a masters degree, a doctorate degree, and executive education courses leading to certificates in various logistics-related disciplines.

The MIT Zaragoza Master in Logistics & Supply Chain Management Program (ZLOG) has been ranked as the #1 Logistics Master in Spain and it is based upon the curriculum of Massachusetts Institute of Technology (MIT) which is ranked as #1 in the US. Our alumni base includes over 500 supply chain professionals in more than 50 different countries. On average 95% of students are hired within 3 months of graduation. The average salary increase for the ZLOG Class of 2011 has been 72%.

The research program uses the logistics park as a working laboratory to experiment with new logistics processes, concepts and technologies, in active collaboration with leading academic institutions and companies from around the world.

MIT-Zaragoza actively engages with companies from around the world to exchange ideas and collaborate on leading-edge research. If your organization would like to collaborate with our faculty, students, and other industry and public sector partners on constantly evolving research projects, there are several outreach opportunities available including Research Groups, Supply Chain Education Partners Program, Symposia, and the Supply Chain Summit.
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