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Water

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## **Executive Summary**

Oasis Water is a company trading in ozonated, filtrated water. The water is bottled on site. The distribution/transport entails only materials, not finished products. The company currently consists of 105 franchises nationwide, only 40 of these franchises produce Oasis juice. The concentrates for these juices are received from a company called Bronpro, situated in Nelspruit. Every franchisee follows its own method of transporting these concentrates.

The Witbank branch was studied in specific, having the largest production capacity. No standard production planning method has been implemented at any of the branches thus far. Witbank's method of production planning and inventory management would be examined. Oasis makes use of a company called Winplas to manufacture their bottles at given rates. Winplas is also responsible for the distribution of materials and would therefore play an important role in the production planning of Oasis water.

The aim of the project is to lower logistics cost regarding the transportation of juice concentrates. Also to investigate the economic order quantity model that can be implemented to improve current deficiencies regarding inventory management. Research will be done in the form of a literature review covering applicable topics.

Two solutions related to both these topics will be presented in the form of this document and a PowerPoint presentation.

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# CHAPTER 1

## Introduction

### 1.1 Introduction and Background

Oasis is a company which sells purified, ozonated water. It was established in 2003. It is a franchised business, and there are currently more than 100 franchises operating in South Africa and in neighbouring countries. Oasis Water was established because of the growing need in cities/suburbs for uncontaminated, harmless water to consume, at an affordable price for all people.

The business came into being coincidentally. An engineer developed the water purifier for an unsuccessful project at work and took the purifier back to his farm thereafter. The decreasing quality of the local water caused him to use the purifier when supplying his labourers with water. After neighbouring farmers and workers also requested the water he realized the business potential and started selling the water from his farm. Oasis water then came into being thereafter.

Each franchise bottles its own water; it is not mineral water and is thus not bottled at one source like most other bottled water products. All the franchises treat the water in a standardized way (ozonate or add oxygen when filtrating) and bottles it in various sizes on site. This makes transportation much less complicated for them than their rivals, as they only have to transport materials and not finished products.

The company has six different quantities in which its products are sold: 330ml, 500ml, 1.5l, 5l, 10l, and 20l bottles. The three products that are sold are: water, juice (concentrate blended with Oasis water) and flavoured water (water which is carbonated with various flavours added). The concentrates Oasis uses to produce their juices is obtained from a company called Bronpro, situated in Nelspruit, Mpumalanga. They currently produce 7 different flavours of juices.

The company's vision is not only to sell their products, but also become a part of the respective communities where their products are sold. They have this opportunity due to the competitive prices of their water. A major competitive advantage which Oasis has over its competitors is that customers have the opportunity to refill their bottles, making their products more cost efficient than their rivals'.

Production planning and control is cardinal to the success of any production company in today's age. Oasis is no exception. The implementation of this concept can determine whether a company has proper control over inventory and is able to meet customer demands when it occurs, resulting in improved customer satisfaction.

The specific branch investigated for the purposes of this project is situated in Witbank. It is the plant with the highest production rate off all the plants, and they supply numerous clients in the Witbank area with Water, also large clients such as the Bhp Billiton owned mine in Witbank.

Oasis Water is a FASA endorsed business opportunity, and practises internationally accepted franchise business principles.

## 1.2 Problem Description

Oasis water currently experiences these critical problems:

- Most Oasis franchises sell the range of Oasis juices, but only 40 of these franchises produce juice. The concentrate for these juices is produced by Bronpro in Nelspruit, Mpumalanga. The distribution of these concentrates is currently handled by Bronpro. Due to the large scale business contracts Bronpro engage in (Ceres etc), the smallest trucks they own are capable of carrying 30tons. This means delivering to each Oasis franchise individually is not deemed feasible currently, as the average demand of these franchises is about 0.6 tons every two weeks. They currently drop off the concentrates at specified points on the main road from Nelspruit to Cape Town, meaning each franchisee has to collect their concentrates at a certain point. Limpopo province in specific was investigated during the course of this project.

With the situation as it currently stands, franchisees can only afford to collect concentrates once every month due to the big expense the trip incurs. This has two major negative implications: a) their cash flow suffers due to the quantity they have to order to justify a trip; b) product availability is very inconsistent, harming the brand image.

- The nature in which the company started had the implication that no standard method of inventory control and procurement was put in place. This is still the case 5 years after the company started. As Oasis, and the Witbank branch in specific, expands and grows the management of inventory becomes a more crucial point from both a financial, and “product image” point of view. A need aroused for a method of forecasting future production, and proper inventory control in order to be able to compete with bigger competitors.

## 1.3 Project Aim and Objectives

The aim of the project will be to lower logistics costs and to propose an alternative method of transport used by the investigated franchisees producing Oasis juices. To implement a standardized method of inventory control to bring about more control over inventory and improved production planning. In a broader sense the aim would be to use standard engineering methods to optimize the functioning of Oasis water and possibly bring about cost savings in the process, by attempting the following objectives:

- Investigate current method of transport of juices, and conduct a cost analysis to determine more cost efficient alternatives.
- Generate alternatives that are relative to the situation Oasis is facing at the moment.
- By analyzing advantages and disadvantages the best alternative can be implemented.
- Analyze methods of inventory control implementing in similar cases to Oasis.
- Study all available methods of inventory management and implement the most feasible one.

## **1.4 Project Scope**

Do a literature review on three main topics:

1. Methods of transportation and various carriers
2. Order quantity models, including safety stock
3. Forecasting and forecasting methods

An in depth industry analysis will be conducted on the different courier industries available. This industry analysis will also include a study of whether private transport could possibly be more efficient. This point will vary from franchise to franchise, but 3 different scenarios will be investigated.

Determining an optimal order policy using the information gained in point 2 of the literature study. The policy should be easily interpreted, and all franchisees should be able to use it. When calculating optimal order quantities for any given policy, one requires the future demands. The only way to accurately determine these demands is to use forecasting methods, which will also be investigated in the literature study (point 3).

Find a feasible solution for the recycling of bottles, and getting them from the franchises to PETCO.

Investigate the cost of patenting a mould unique to Oasis water (for each of the volumes produced), and whether the manufacturing of the new patent justifies the initial cost with long term cost savings.

## **1.5 Conclusion**

The Project was undertaken to improve logistics and inventory management at Oasis water. These two topics were chosen after analyzing the problems in the first phase of the project. Thereafter the problems were properly described and scoped in order to determine the extent of the project.

The aim and objectives of the project was then stipulated, in order to determine the topics on which a literature review could now be conducted. The standard engineering methods that will be used was also decided upon, and a project plan was drawn up to illustrate the timeline of the project.

# **CHAPTER 2**

## **Literature Study**

### **2.1 Introduction**

With the fuel price increasing drastically in recent years, transportation of goods has become a bigger more complex problem for companies worldwide. Transportation is vital when considering topics such as product availability and Lead time to delivery. The price and reliability of transport plays a crucial role in the success of any business and therefore different methods of transportation will be studied to determine the best alternative.

Managing inventory is the key to avoid problems such as stock outs or excessive holding costs of material. All Materials (bottles, caps and labels) which Oasis water uses are available continually because of the magnitude of their suppliers. The only section of production planning that has to be investigated is the inventory control, more specifically economic order quantity models.

An integral part of Economic order quantities is the forecasting of the demand of the product in future. Different methods of forecasting had to be studied in order to use the models available.

### **2.2 Logistics**

#### ***2.2.1 Third-Party Logistics (3PL)***

Third-party-logistics occur when a company outsources all or part of its logistic functions to a specializing in logistical activities. Some 3PL providers are skilled in specific areas of logistics, for example 'transportation based' 3PL providers, specializing in transportation.

Coyle, Bardi & Langley (2003)

#### ***2.2.2 Public or Private Transportation***

The main decision is whether a company should purchase means of transportation, or outsource it to a 3PL firm. Public methods of transportation entail only variable cost. When the volume transported increases the cost of outsourced/public transport will rise proportionally. Private transportation has a fixed cost element initially (and also depreciation over time). The advantage however is that the variable portion of transportation operating costs (fuel, depreciation) will increase at a slower rate than public transportation. This means that at some point the two functions will be equal. For lower volumes transported it is better to make use of public transportation, and for very high volumes transported on a regular basis it would be better to make use of private means of transportation.

Coyle, Bardi & Langley (2003)

For the purposes of Oasis water it would be more beneficial to make use of third-party logistics, more specifically transportation based 3PL, due to the relatively small volume and frequency of their transportation needs.

### 2.2.3 Motor Carriers

There are two main types of carriers in the motor carrier industry, namely for-hire and private carriers. Private carriers are owned by the firm whose goods are transported. For-hire carriers can be categorized in three different divisions:

- I. Regulated – Not subject to common carrier obligations, but held liable for damage to goods
- II. Contract – Does not serve the common public, serves a restricted number of shippers. Governed by the terms and conditions of the contract signed by both parties. Renowned for providing an expert service to the shipper, meeting the shippers specific requirements.
- III. Exempt – Specifically excluded from federal economic regulations. The rates are determined by the market, the laws of supply and demand.

A distinctive characteristic of the motor carrier industry is the large number of small carriers. The two main advantages of motor carriers are their transit time and accessibility.

Coyle, Bardi & Langley (2003)

### 2.2.3 Negotiating with Carriers

Negotiating factors between the shipper and the carrier is determined by the marketplace. These factors will include the tariffs and services provided by the carrier. The needs of the shipper mostly initiate the negotiations. The carrier then responds positively, or with a counterproposal which offers something less than what the sipper requested. [2]

## 2.3 Inventory Management

Historically, inventory was viewed as a measure of wealth and was viewed as an asset to a company. Only in recent years companies started viewing inventory as a liability due to the movement and holding costs in entails. This led to the development of various models, such as the “just-in-time” model designed with the purpose of keeping inventory levels as low as possible.

According to Waters (1992), inventory is kept to “provide a buffer between variable and uncertain supply and demand”. The main target when managing inventory is to find the optimal balance between having enough stock to provide a demand for a product at a specified success rate, and keeping stock levels low enough in order to minimize holding cost.

Stock can be classified into three categories, and the relationship between these categories is given by Waters (1992) as follows:

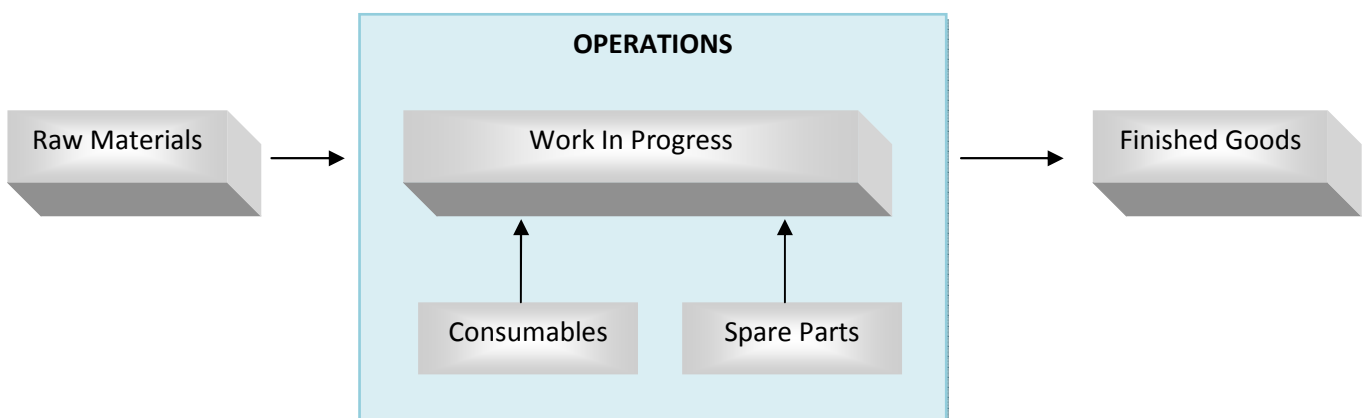


Figure 1: Classification of stock

### 2.3.1 EOQ (Economic Order Quantity) models

EOQ models can only be applied when the demand is constant. Peterson and Silver (1988) came up with an algorithm to determine whether EOQ models can be accurately applied or not. Assume demands  $d_1, d_2, \dots, d_n$  was observed over  $n$  periods of time, and the future demands can be predicted with enough accuracy to assume a deterministic demand. According to Winston (2004) applicability of the EOQ model can then be calculated in three steps:

i) Determine the estimate  $\bar{d}$  of the average demand per period given by

$$\bar{d} = \frac{1}{n} \sum_{i=1}^{i=n} d_i$$

ii) Determine an estimate of the variance of the per-period demand  $D$  from

$$\text{Est. var } D = \frac{1}{n} \sum_{i=1}^{i=n} d_i^2 - \bar{d}^2$$

iii) Determine an estimate of the relative variability of demand, named  $VC$ :

$$VC = \frac{\text{est.var } D}{\bar{d}^2}$$

Peterson and Silver's research indicated that a value of  $VC < 0.20$  is sufficient to use EOQ. For values of  $VC$  greater than 0.2, dynamic programming methods should be used.

#### 2.3.1.1 Ordering and setup cost

This cost stays the same regardless of the order size or length of the production run. Costs required initiate an order. If products are produced and not ordered, the setup cost will include the cost of labor when setting up and shutting down machines involved with production.

#### 2.3.1.2 Holding/carrying cost

According to Rowbotham, Galloway & Azhashemi (2007) [3] it can be defined as "the cost of carrying one unit of inventory for one time period." They [3] define 5 main components making up the holding cost of a product:

- I. *Interest* – when capital used to purchase stock is borrowed, the interest paid is seen as holding cost.
- II. *Insurance* – when stock is insured against certain damages like theft etc.
- III. *Council tax* – cost incurred when buildings in which stock is kept gets taxed by local authority
- IV. *Deterioration in value* – value of stock decreases over time
- V. *Stock management* – material in a company's possession requires handling and surveillance, these costs also count as holding cost

Another important fraction of holding cost is opportunity cost. This cost type is seen as the possible return capital invested in inventory, which could have been invested elsewhere, for example: if a business could earn 20% annually when investing capital and the unit cost is R50, the holding cost for one unit per annum will be R10.

### 2.3.1.3 Stockout/shortage cost

Shortage cost occurs when a consumer requests a product and the request cannot be fulfilled in the specified time. If the consumer/customer is willing to accept his request at a later point than the time stipulated, the request will be *back ordered*. If not, the case can be described as a *lost sales* case. Back orders will most often incur higher costs than a usual order. Stock-out costs are difficult to measure. These costs occur when a company isn't able to meet a consumers request in time, the consumer may get the product from a different source, meaning not only loss of sales but also lost goodwill.

### 2.3.1.4 Assumptions of EOQ models [6]

- Recurring orders/ordering = orders are repeated regularly per time span, no "once only" orders.
- Constant Demand = Demand occurs at a constant rate over a time period
- Constant Lead Time = the lead time (time between placement of order and receiving of order) stays constant, L.

### 2.3.1.5 Multiperiod Inventory Systems

Two types of systems occur, fixed-order quantity models (EOQ) and fixed-time period models (periodic system). The purpose of multiperiod inventory systems is to ensure the continuous availability of a product in a business. [2]

#### *Safety stock*

The safety stock level is calculated according to the service level a company wants to provide. If the demand of a product is normally distributed, the safety stock is calculated as follows:

#### *Fixed-order quantity Model*

$$SS = Z\theta_L$$

Where  $Z$  = the number of standard deviations for a specific service probability

$\theta_L$  = Standard deviation of usage during lead time

#### *Fixed-time period Model*

$$SS = Z\theta_{L+T}$$

Where  $Z$  = the number of standard deviations for a specific service probability

$\theta_{L+T}$  = Standard deviation of usage during lead review time

### 2.3.1.6 Fixed-order quantity Model or Fixed-time period Model

The fixed time period model is known to have larger average inventory levels. This is due to the fact that they have to have a buffer of inventory to lower the risk of a stockout during the review period.

For more costly items it will be more suitable to use the fixed-order quantity model, because the average inventory levels are lower

The Fixed-order quantity model is capable of a better response time than the Fixed-time period model, and has therefore a lower risk of a potential stockout. It is also however more time consuming because it requires continuous monitoring of inventory levels.

### 2.3.1.7 Fixed-order quantity Model (with safety stock)

A new order is placed every time the inventory reaches a predetermined level  $R$  (reorder point). The risk of a stockout can thus only occur after the inventory dips below  $R$ , until the new order is received. This period is known as the lead time,  $L$ . The quantity to be ordered,  $Q$ , is calculated taken the following aspects: demand, setup cost and holding cost.

The reorder point is calculated as follows:

$$R = dL + Z\theta_L$$

$d$  = average daily demand

$L$  = Lead time in days

$Z\theta_L$  = as defined above

The optimal order quantity is calculated as follows:

$$Q_{opt} = \sqrt{\frac{DS}{H}}$$

$D$  = Annual demand of product

$S$  = Setup cost of placing an order

$H$  = annual holding/storage cost per unit of average inventory

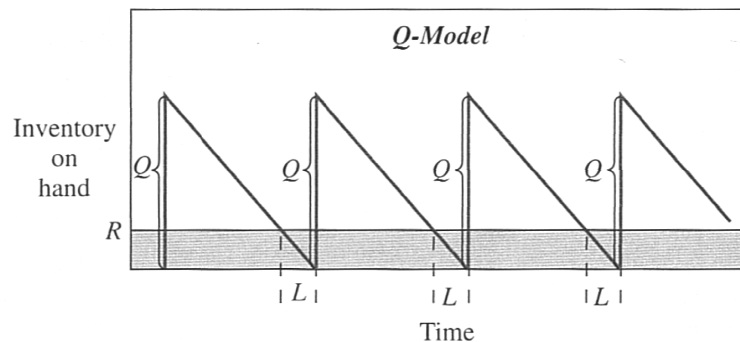


Figure 2: Basic Fixed-Order Quantity Model

The formal calculating the total cost is as follows:

Total annual cost = Annual purchase cost + Annual ordering cost + Annual holding cost

$$TC = DC + \frac{D}{Q}S + \frac{Q}{2}H$$

$TC$  = Total annual cost;  $C$  = Cost per unit;  $Q$  = Quantity to be ordered

$D$ ,  $S$ ,  $H$  = as defined above

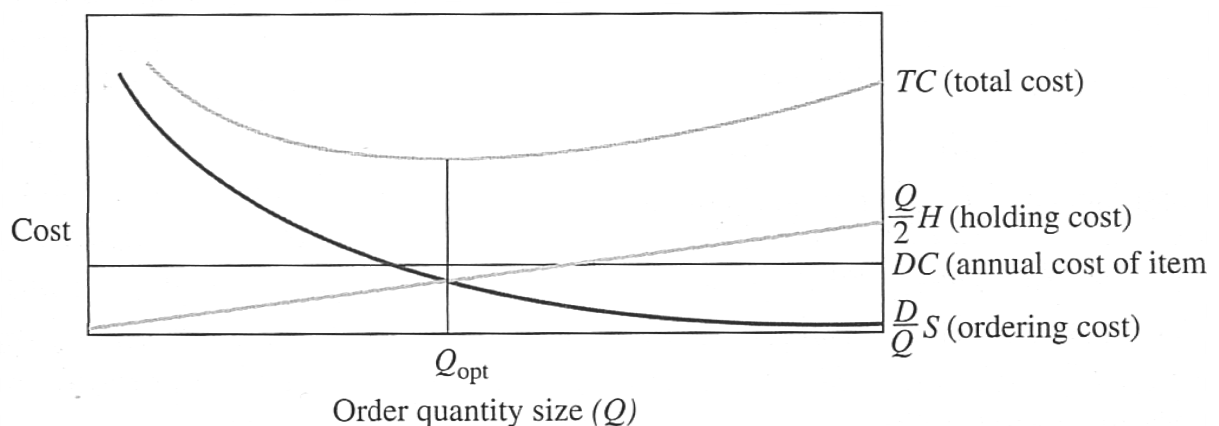


Figure 3: Annual Product costs, relative to order size



## **2.4 Forecasting**

The purpose of forecasting is to use most likely future scenarios to assist with decision making in the present.

According to the Walonick (1993) there are numerous important assumptions regarding forecasting:

1. The future cannot be predicted with 100% accuracy. There will always be an element of uncertainty until the forecast horizon comes to past.
2. There will always be blind spots in forecasts. It is impossible to forecast entirely new technologies for which there are no existing paradigms.
3. Providing forecasts to policy-makers will help them formulate social policy. The new social policy, in turn, will affect the future, thus changing the accuracy of the forecast.

There are four main recognized groups of forecasting:

- qualitative
- time series analysis
- casual relationships
- simulation

Qualitative techniques can be expressed as biased because of the fact that they are derived from approximations and people's judgment. Time Series analysis is derived from the concept that relative data from the past can be used to predict future scenarios. Casual forecasting is based on the idea that future demands are influenced by factors in the environment. Simulation models are dynamic models, they create the opportunity for the forecaster to make assumptions about internal variables and external environment in the model. The forecaster can view different outcomes for different inputs to the model.

### ***2.4.1 Qualitative Techniques in Forecasting***

#### **2.4.1.2 Grass Roots**

Forecast is made up by adding input from those at the end of the hierarchy who deal with what is being forecast. The person closest to the customer or end user of the product knows its future needs best. Forecasts at this bottom level are added together and given to the next higher level.

Jacobs & Chase (2009)

#### **2.4.1.3 Market Research**

Market research is mainly utilized for the purpose of finding new product ideas, preference and indifferences about current products, which competitive products within a particular class are preferred etc. Data collection exists primarily out of surveys and interviews.

Jacobs & Chase (2009)

#### **2.4.1.4 Panel Consensus**

Panel forecasts involve meetings where ideas and concepts can be exchanged between all employees, regardless of position, in a firm. The main motivation for this forecasting type is that a group can generate ideas collectively than any one individual by him/herself.

Jacobs & Chase (2009)

#### **2.4.1.5 Historical Analogy**

The item being forecasted can be modelled from a similar item in the same industry. It plays a significant role when planning new products, because a forecast may be derived by using the history of a similar product.

Jacobs & Chase (2009)

#### **2.4.1.6 Delphi Method**

A group of skilled people is involved in completing a questionnaire. A moderator compiles results and formulates a new questionnaire which is submitted to the group. Thus, there is a learning process for the group as it receives new information and there is no influence of group pressure or dictating individuals. The Delphi method conceals the identity of the individuals participating in the study. Everyone has the same weight.

Jacobs & Chase (2009)

### ***2.4.2 Casual Relationship Forecasting***

A casual relationship is based on the principle that one incident causes another. If the causing element is known far enough in advance, it can be used as a basis for forecasting.

#### **2.4.2.1 Economical Models**

Economical models attempts to describe some sector of the economy by a series of mutually dependent equations.

#### **2.4.2.2 Input / Output Models**

This model focuses on sales of each industry to other firms and government. The model also indicated changes in sales that a producer industry might expect because of purchasing changes by another industry.

#### **2.4.2.3 Leading indicators**

Leading indicators consist of statistics which move in the same direction as the series being forecast, but move in front of the series.

### ***2.4.3 Combining Forecasting techniques***

All the forecasting techniques have some flaws when applied in different scenarios. According to Walonick (1993) [5] there is substantial evidence to demonstrate that combining individual forecasts produces gains in forecasting accuracy. The optimal combination of different forecasting methods has however not been researched yet.

Over short periods forecasting becomes a necessity when determining material requirements. Forecasting is a very powerful tool because it gives a business to make alterations in the present to change the possible future outcome.

The advice given to Oasis water in this regard would be to combine two forecasting methods. The two suggested methods would be 'Panel Consensus' and 'Economical Models'. The reason being that the panel of experts should have enough knowledge about the demand patterns of water seeing that it is season bound and varies little from one specific season to a similar one in the next period. Also the demand of water will be influenced by the current economic state, being the other major role-player when forecasting the demand.

## **2.5 Conclusion**

Two main topics were researched during chapter two.

1. Logistics, more specifically transportation management
2. Inventory control, specifically EOQ models and forecasting methods to determine demand.

The literature study was conducted in order to determine the best possible engineering methods to correct the problems identified during chapter 1.

During chapter 3 and 4 the best alternatives identified in chapter 2 will be applied in a manner relevant to the nature of the company, catering for their financial and quality specifications.

# CHAPTER 3

## Industry Analysis

### 3.1 Current state of affairs

In Limpopo province, three franchisees currently produce fruit juices:

- Polokwane
- Louis Trichardt (Makhado)
- Nylstroom (Modimolle)

The three of these obtain their concentrates in Witbank, and they have to obtain it using their own method of transportation.

Due to the large cost implication of a trip these franchisees only acquire concentrates once per month on average, resulting in stock outs and excessive stock levels.

For each of these franchisees, two cost estimates were calculated per trip. One according to AA tariffs and another indicating the actual cost incurred. The Polokwane franchise was used as an example:

Distance travelled from Polokwane to Witbank and back: 570 km

Cost according to AA tariffs for a 2700 cc diesel truck: **R 6 623.40** (570 km @ R 11.62c p/km)

Actual cost incurred (as provided by franchisees):

- Diesel	R 998.40
- Salaries : 2 labourers, half a day	R 225.00
- Overtime : 2 labourers, 4 hours each	R 225.00
- Toll tariff	<u>R 0.00</u>
- <b>Total</b>	<b>R 1498.40</b>

This process was repeated for each of the other three franchisees, the numbers were as follows:

<u>Branch</u>	<u>AA tariff cost</u>	<u>Actual cost</u>
Louis Trichardt	R 9 993.20 (860km)	R 2 275.36
Nylstroom	R 5 112.80 (440 km)	R 1 270.70

For the purposes of this project the AA tariffs will be used, as it brings all explicit and implicit costs incurred per km into consideration. It is also the standardized, recognized measure of cost.

The demand rate of juice concentrates for these three franchisees are quite similar. They all use about 64 boxes every 2<sup>nd</sup> month (20l of concentrate at R450 per box, 32 boxes making up one pallet). All of the franchisees would prefer stock every month in order to improve their cash flow and prevent the risk of a stockout, improving product reliability.

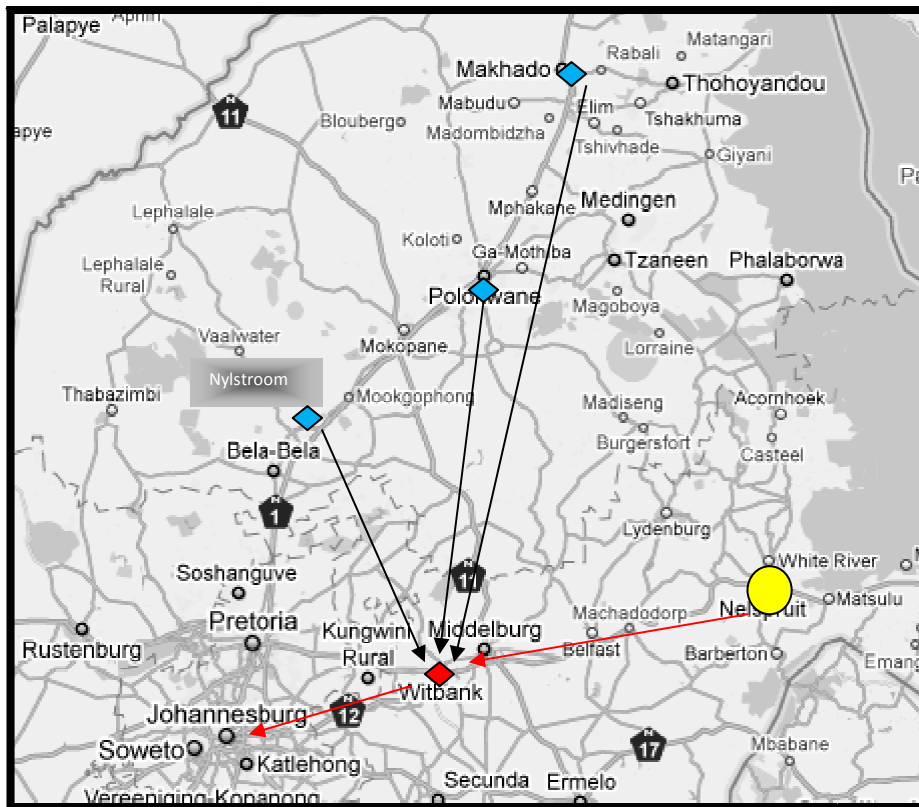


Figure 5: Geographical distribution of Limpopo franchisees

- ◆ = Oasis franchisees in Limpopo producing juice
- ◆ = Destination at which Limpopo franchisees collect concentrates currently
- = Location of Bronpro, producer and supplier of juice concentrates

Accumulative this would imply a demand of 96 boxes once every month, about 2.3 tons.

The total cost spent on transport between the three franchisees (according to AA tariffs) is R 21 729.40 per trip, occurring on average once every two months (6-8weeks).

The juices produced by Oasis have only been added to their product range in the past 2 years and the demand for these products is growing quickly. There is a realistic possibility that some of the other 6 branches in Limpopo might also start to produce juices. This will increase the cost spent on transport per month even more.

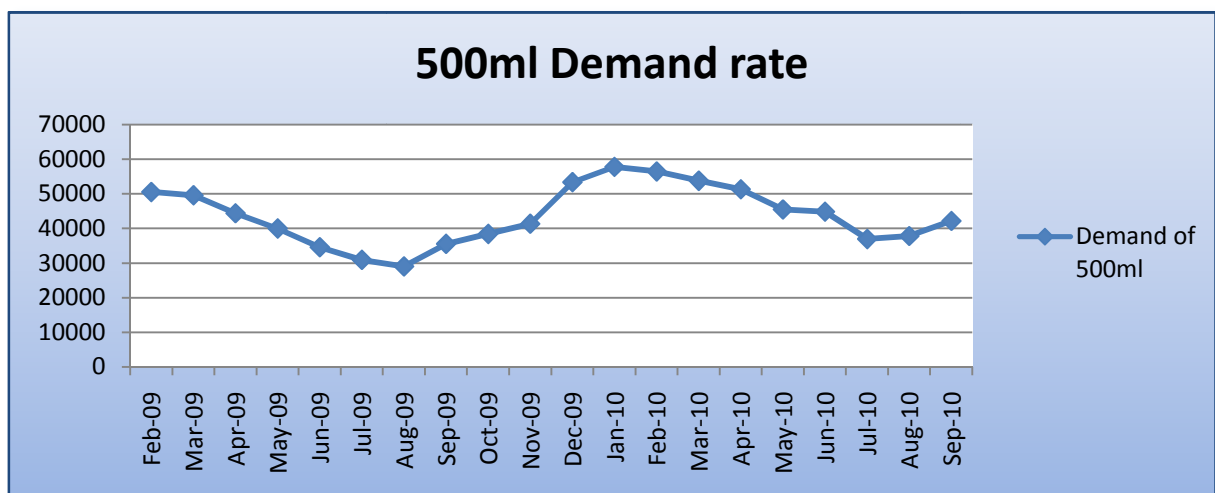
### 3.2 Current state of inventory management

The only materials ordered by Oasis Witbank are bottles, caps and labels. All these are received from a company called Winplas, specializing in the manufacturing of plastic bottles and related materials on a very large scale. Due to the large scale at which Winplas does business, availability of materials is not an issue. The assumption can be made that whenever an order is placed Winplas will be able to comply with that order within 1 or 2 days.

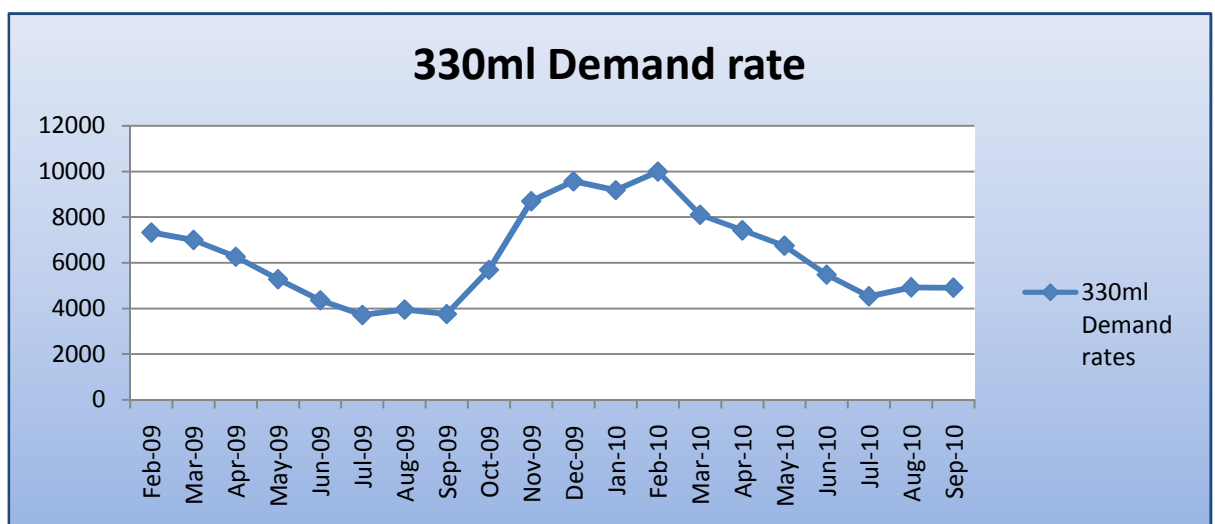
Three different products investigated over the past 20 months varies only in size, it is the 330ml, 500ml, 1.5/ bottles. Due to the fact that these products all have the same quality, only differing in quantity, the demand patterns for all 3 are fairly similar. The demand rate for the other quantities' wasn't large enough to justify an EOQ model approach.

After studying the demand trends (illustrated in the three tables that follow) it became evident that the basic EOQ model would not be truly reflective. One of the assumptions of the basic EOQ model is that the demand is constant over a certain period. When analysing the trends of the three products, this is clearly not the case.

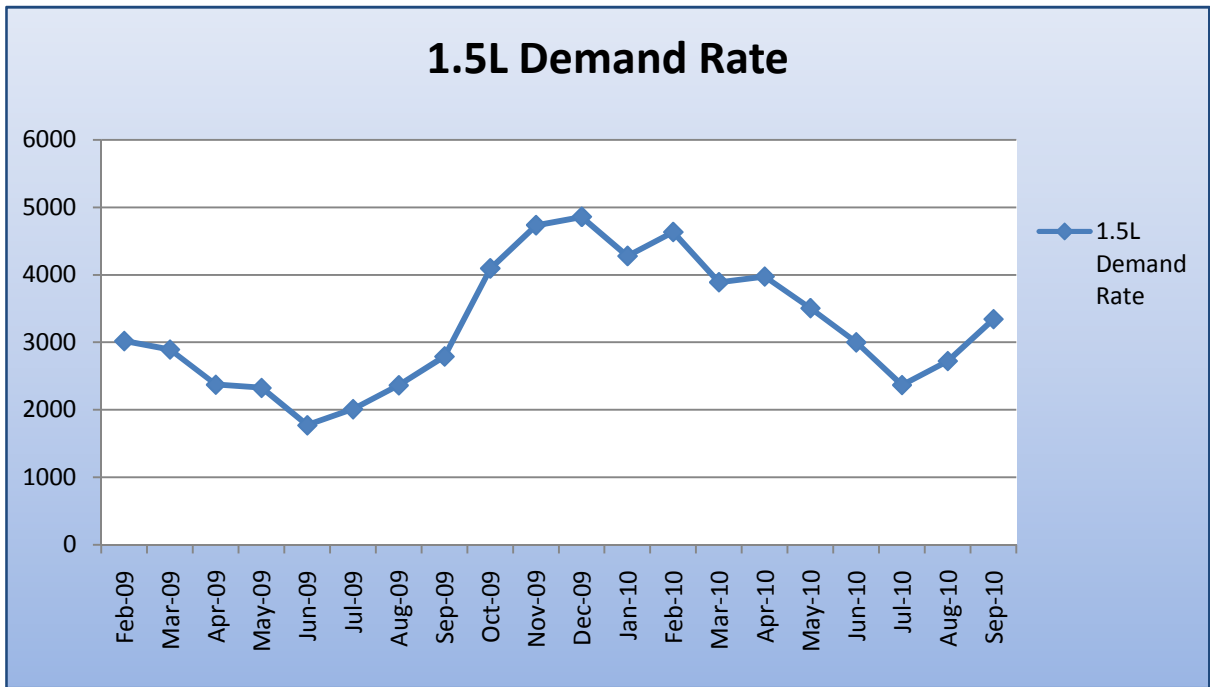
The demand of water is very dependent on seasons and during the winter demand decrease dramatically. In order to determine whether the demand for a product follows an exponential curve or not one has to evaluate as much historical data as possible, Oasis was only able to provide the last 20 months' statistics. The Demand for the three quantities investigated is illustrated in three tables below.



Graph 1: Demand of 500ml bottles



Graph 1: Demand of 330ml bottles



Graph 1: Demand of 1.5L bottles

Due to the seasonal nature of demand, it is not possible to draw up an exponential curve to indicate a linear trend in the natural logarithmic values of successive demand values. This would have been proof of the fact that the demand varies in an exponential nature. However, when comparing values separated by 12 months (February with February, March with March etc) it becomes evident that the demand increases exponentially from year to year. This also makes it possible to determine an exponential growth rate for each of the quantities, making the exponential EOQ model possible.

During chapter 4, the EOQ formula for exponential demand will be derived, and the optimal Economic order quantity will be determined using both the exponential- and basic EOQ models. Chapter 5 will consist of testing and validating the most accurate one of these two methods.

## CHAPTER 4

### System Design and Implementation

#### 4.1 Logistical Problem

Two alternatives were considered for the solution. The first was to investigate the opportunity of buying a delivery vehicle only for the purpose of the three franchises. This alternative was immediately discarded due to the large cost involved with buying a new truck, for the purposes of this small scale problem it was not feasible. None of the three franchisees have a truck big enough to cater for the needs of all three franchises in one trip, so this was also not an alternative.

The “Third Party Logistics” topic studied in Chapter 2.2.1 was now considered. The solution proposed, was outsourcing the problem to a specialist distribution company. These companies specialize in distributing numerous small loads to the same location, making them much more cost efficient. These companies supply businesses like Spar and Pick ‘n Pay, making up a full load out of numerous small loads, and they distribute to almost every town in South Africa.

The most cost efficient and accessible company for this purpose was Vital Distribution Solutions, situated in Nelspruit, the city where the suppliers of concentrates, Bronpro, is situated.

After negotiating with the carrier (Vital Distribution Solutions), they agreed on delivering the products at 10% of the value of an order. As mentioned in Chapter 3, the accumulative demand of the three franchises is 96 boxes (one pallet each) once every month, about 2.3 tons. The value of these 96 boxes is R43 200. 10% of this amount equals R 4 320 per month, and will be divided among the three franchisees in relation to the distance they are from the source.

Although this expense occurs once every month as opposed to once every two months in the current state of affairs, it still results in a saving for all three franchisees:

<u>Branch</u>	<u>AA tariff Cost per trip</u>	<u>Actual cost per trip</u>	<u>Proposed solution cost per trip</u>
Polokwane	R 6 623.40	R 1 498.40	R 1 222.64
Louis Trichardt	R 9 993.20	R 2 275.36	R 1 630.19
Nylstroom	R 5 112.80	R 1 270.70	R 1 467.17

As mentioned the concentrates will now be delivered once per month, instead of once every 2<sup>nd</sup> month. To compare the costs incurred every 2<sup>nd</sup> month, a new table will be drawn up:

<u>Branch</u>	<u>AA tariff Cost every 2<sup>nd</sup> month</u>	<u>Actual cost every 2<sup>nd</sup> month</u>	<u>Proposed solution cost every 2 months</u>
Polokwane	R 6 623.40	R 1 498.40	R 2 445.28
Louis Trichardt	R 9 993.20	R 2 275.36	R 3 260.38
Nylstroom	R 5 112.80	R 1 270.70	R 2 934.34

Even though the solution cost is higher than the actual cost incurred currently, it would still be better than the current state of affairs for the following reasons:

- When compared to the AA tariffs, which is the generally accepted norm, the franchisees save R 4 178.12, R 6 732.82 and R 2 178.46 respectively. The AA amount includes the depreciation of vehicles due to the trip and other implicit costs making it more reflective than the actual cost calculated.
- The labor used during the day can now be utilized in a different manner.
- The risk involved with undertaking the trip (risk of an accident, risk of theft etc) is eliminated
- By ordering stock once every month as opposed to once every 2 months, the cash flow of the franchise improves drastically.
- As mentioned before, the product reliability improves as the risk of a stockout decreases considerably due to more regular replenishment of inventory.

This solution will be beneficial out of a long term perspective. As new franchises in Limpopo start to produce fruit juices, the bargaining power of Oasis will increase, and the cost of distribution will decrease even more as Oasis will occupy more space per delivery.

## 4.2 Formulating the EOQ model

In chapter 2 the basic EOQ model was studied thoroughly. After receiving some information regarding the demand in chapter 3, it became evident that the demand might follow an exponential trend. The need arose to study a model that could incorporate the exponential demand in an EOQ format.

Juneau and Coates (2001) used these symbols and methodology to denote the variables needed compute both the basic EOQ model and the EOQ model for exponential demand:

$C_h$  = holding cost (i.e., R per unit per time period)

$C_o$  = ordering cost (i.e., R per order)

$D$  = demand rate (i.e., units per time period)

$EOQ$  = economic order quantity (constant demand)

$Q$  = order quantity

The following assumptions regarding the model, as mentioned in Chapter 2, have to be made:

- Ordering and holding cost must be known – it is known, it varies for each quantity but the values are given in tables 2-7
- The holding cost is assumed to be directly proportional to the average inventory level – This is also the case, as is shown in tables 2-7
- The demand has to be exponentially distributed – explained in chapter 3
- Lead time  $T$  is constant

EOQ models related to exponential growth was examined by Juneau and Coates (2001). The equations following was in attempt to prove the exponential EOQ model from the EOQ model for generalized demand (basic model), ultimately to lower cost.

The differential describing the behaviour of the inventory over time where  $D(t)$  is the demand at time,  $t$  is given by:

$$\frac{dI(t)}{dt} = -D(t) \quad (1)$$

Let  $T$  be the time at the end of the order cycle and  $t_0$  the time at the beginning of the cycle then the boundary conditions for equation (3) are:

For the inventory over time,  $I(t)$ , yields:

$$I(t) = \int_t^T D(s)ds \quad (2)$$

From equation (2) the order quantity  $Q$  can be obtained:

$$Q = I(t) = \int_t^T D(s)ds \quad (3)$$

In order to determine the holding cost one the average inventory levels has to be determined first.

$$I_{avg}(t_0) = \frac{1}{T-t_0} \int_{t_0}^T I(s)ds = \frac{1}{T-t_0} \int_{t_0}^T \left[ \int_{t_0}^T D(u)du \right] ds \quad (4)$$

Changing the order of integration yields:

$$I_{avg}(t_0) = \frac{1}{T-t_0} \int_{t_0}^T \left[ \int_{t_0}^u D(u)ds \right] du \quad (5)$$

The expression is then integrated, as a function of the time dependant demand:

$$I_{avg}(t_0) = \frac{1}{T-t_0} \int_{t_0}^T (u - t_0)D(u)du \quad (6)$$

The cost should be expressed as function of the period of the order cycle in order to simplify the derivation. The total of the ordering and holding cost becomes:

$$f(t_0) = \frac{C_0}{T-t_0} + C_h I_{avg}(t_0) \quad (7)$$

Substituting equation (6) into (7) yields:

$$f(t_0) = \left( \frac{C_h}{T-t_0} \right) \left[ \frac{C_0}{C_h} + \int_{t_0}^T (u - t_0)D(u)du \right] \quad (8)$$

The minimum cost can now be derived as a function of the cycle duration by taking the derivative of the total cost equation (8) and equating the derivative to zero.

$$f'(t_0) = 0 = \left( \frac{C_h}{(T-t_0)^2} \right) \left[ \frac{C_0}{C_h} + \int_{t_0}^T (u - t_0)D(u)du \right] + \left( \frac{C_h}{T-t_0} \right) \left[ \frac{d}{dt_0} \left( \frac{C_0}{C_h} + \int_{t_0}^T (u - t_0)D(u)du \right) \right] \quad (9)$$

Thus:

$$\left( \frac{1}{T-t} \right) \left[ \frac{C_0}{C_h} + \int_{t_0}^T (u - t_0)D(u)du \right] + \frac{d}{dt_0} \left( \int_{t_0}^T (u - t_0)D(u)du \right) = 0 \quad (10)$$

The derivative of the integral can be found using Liebnitz's rule:

$$\frac{d}{dt_0} \int_{t_0}^T (u - t_0) D(u) du = -(t_0 - t_0) D(t_0) + \int \frac{d}{dt_0} [(u - t_0) D(u)] du = - \int_{t_0}^T D(u) du \quad (11)$$

Substituting the results of (11) into (10) gives:

$$\left( \frac{1}{T-t_0} \right) \left[ \frac{C_0}{C_h} + \int_{t_0}^T (u - t_0) D(u) du \right] - \int_{t_0}^T D(u) du = 0 \quad (12)$$

Multiplying by  $(T - t_0)$  and combining terms yields the following equation:

$$\frac{C_0}{C_h} = \int_{t_0}^T (T - u) D(u) du \quad (13)$$

Then substituting  $x = T - u$ , results in the final relationship:

$$\frac{C_0}{C_h} = \int_0^{T-t_0} x D(T - x) dx \quad (14)$$

The relationship in equation 14 can be used to derive the classical EOQ. In the classical EOQ, the demand is constant. Let the demand,  $D(t) = D_0$ . Then the relationship in (14) becomes:

$$\frac{C_0}{C_h} = \int_0^{T-t_0} x D_0 dx = D_0 \left( \frac{(T-t_0)^2}{2} \right) \quad (15)$$

The EOQ,  $Q$ , can also be known using equation (3).

$$Q = \int_{t_0}^T D_0 du = D_0 (T - t_0) \quad (16)$$

(15) Should now be multiplied by  $D_0$  and the expression for  $Q$  from (16) must be substituted to result in the following:

$$D_0 \frac{C_0}{C_h} = \frac{(D_0 (T-t_0))^2}{2} = \frac{Q^2}{2} \quad (17)$$

Solving (17) for  $Q$ , gives the classical EOQ formula:

$$Q = \sqrt{\frac{2D_0 C_0}{C_h}} \quad (18)$$

The following equations are derived for exponential demand by using the equations derived for constant demand:

For an exponential demand, let  $D(t) = D_0 e^{\alpha t}$  where  $\alpha$  is a parameter presenting exponential growth in demand. Using the optimum relations obtained in equation (14) and the equation representing exponential demand the economic quantity can be calculated:

$$Q = \int_{t_0}^T D_0 e^{\alpha t} dt = \frac{D_0 e^{\alpha t}}{\alpha} [e^{\alpha(T-t_0)} - 1] \quad (19)$$

Equation (19) can present the economic quantity if the cycle length,  $(T - t_0)$  were known. The optimal relationship in equation (14) can be used to calculate the optimal cycle length.

The optimum relationship in equation (14) becomes equation (20) for exponential growth:

$$\frac{C_0}{C_h} = \int_0^{T-t_0} \alpha D(T-x) dx = D_0 \int_0^{T-t_0} x e^{\alpha(T-x)} dx \quad (20)$$

Evaluating the integral in (20) then becomes:

$$\frac{C_0}{C_h} = \frac{1}{\alpha^2} D_0 e^{\alpha T} - \frac{1}{\alpha^2} [1 + \alpha(T - t_0)] D_0 e^{\alpha t_0} \quad (21)$$

Substituting  $D(t_0) = D_0 e^{\alpha(T-t_0)}$  and then dividing by  $D(t_0)$  yields:

$$\frac{\alpha^2 C_0}{D(t_0) C_h} = e^{\alpha(T-t_0)} - [1 + \alpha(T - t_0)] \quad (22)$$

Defining the value of  $\beta = \alpha(T - t_0)$  simplifies (22) into:

$$1 + \frac{\alpha^2 C_0}{D(t_0) C_h} = e^\beta - \beta \quad (23)$$

Redefining the quantity on the left as the constant, it leads to:

$$1 + \frac{\alpha^2 C_0}{D(t_0) C_h} = k \quad (24)$$

A final step is to determine a value for  $\beta$  that satisfies equation (23). Newton's method can be used for this procedure. Expanding the generalized EOQ relationship in the Taylor series in  $\beta$  and then ignoring the terms higher than the second power of  $\beta$  the initial guess for Beta can be derived. The following can be used for the initial value of beta:

$$\beta_0 = \frac{\alpha^2}{D(t_0)} \sqrt{\frac{2C_0 D(t_0)}{C_h}} \quad (25)$$

Then use the following equation (26) for the recursion:

$$\beta_{n+1} = \frac{(\beta_n - 1)e^{\beta_n} + k}{e^{\beta_n} - 1} \quad (26)$$

After the value for  $\beta$  has been determined substitute the following equation  $\beta = \alpha(T - t_0)$

$$(T_0 - t_0) = \frac{\beta}{\alpha} \quad (27)$$

Now the optimal quantity can be derived:

$$Q = \frac{D(t_0)}{\alpha} (e^\beta - 1) \quad (28)$$

In equation (28) when  $\alpha$  tends towards zero, Q converges to:

$$Q = \sqrt{\frac{2D_0 C_0}{C_h}}$$

giving the basic EOQ model.

The model based on exponential growth can now be implemented in Oasis' case, making it relevant to the data collected in chapter 3. The implementation of these calculations can be witnessed in Appendixes A to C.

## CHAPTER 5

### Testing and Validation

	<i>500ml</i>	<i>330ml</i>	<i>1.5L</i>
Exponential EOQ Average	<b>32402</b>	<b>4495</b>	<b>2714</b>
Basic EOQ Average	<b>32273</b>	<b>4461</b>	<b>2657</b>

Table 1: *Exponential EOQ vs Basic EOQ*

In all the cases witnessed in the table above, the exponential EOQ averages are higher than those for the basic EOQ model. This is due to the fact that the exponential model takes the exponential growth of the product into consideration when calculating the optimal quantity. The results however indicate that there is a small difference in the values of the exponential and the basic EOQ models. This is due to the small value of exponential growth,  $\alpha$ . The longer Oasis remains in production, the more narrow the gap between these two values will become. The basic EOQ model would seem to be sufficient to meet Oasis needs in determining the optimal order quantity.

It should however still be more beneficial to make use of the exponential model for the time-being. These averages or calculated for a one month period, and over the course of a year the difference between the two values will naturally be much bigger, having a bigger influence on the optimal quantity ordered.

## CHAPTER 6

### Conclusion

Oasis water is relatively new to the water industry. Applying standard engineering methods as part of their business plan could improve the company's position drastically. During Chapter 1 it was determined that Oasis has two main problems that needed to be addressed. The first being a lack of proper inventory control and order policies. The second was the fact that transportation cost of juice concentrates is very high, and the rapid rate at which Oasis is expanding makes an alternative to this problem a critical point.

The main aim of the project was to lower transportation costs and implement an inventory control method that would help Oasis water to lower the risk of stock outs and maintain a minimum level of inventory reducing holding costs.

During Chapter 2 literature relevant to both these topics were studied in order to determine possible engineering methods to solve the problems identified in Chapter 1. The first section of Chapter 2 was dedicated to studying literature relevant to transportation, specifically with motor carriers. The second part of Chapter 2 entailed literature related to inventory control and different order policies. Rowbotham (2007) and Jacobs (2009) were the two main resources used during this chapter. During the latter part of this Chapter, the article by Juneau and Coates (2001) was used to study the functioning of an exponential EOQ model, due to the fact that the demand is not always constant as assumed in the basic EOQ model.

Chapter 3 the relevant data was gathered to address the problems identified in the first chapter. After studying the data it became evident which of the methods studied in Chapter two were most suited for the two problems. Regarding the transportation problem, it became evident that transporting such a small quantity of concentrates with an own method of transportation incurs very high cost. The second problem indicated that the demand rate for the products investigated is not constant. Analysing the data on a year-to-year basis showed that the demand does increase exponentially, but at a relatively small rate.

In Chapter 4 it was suggested that an alternative method of transportation be used. It was shown that outsourcing the distribution of concentrates to a company called Vital Distribution Solutions would save each franchisee involved a substantial amount of time and money. The alternative proposed would also ensure more reliable availability of stock, and improved cash flow for each franchisee. During the second part of the chapter, the model for exponential demand by Juneau and Coates (2001) was illustrated, making it possible to implement the model to determine the optimal EOQ. The model was then implemented, and the results were obtained.

Chapter 5 was dedicated to testing and validating the results obtained in Chapter 4. It was illustrated that the exponential EOQ model is more reflective and more accurate than the basic EOQ model. By implementing this model, Oasis can improve the reliability of their product, minimize storage cost and reduce the risk of stock-outs in a significant manner.

## CHAPTER 7

### References

- [1] Coates ER, Juneau J (2001) 'Economic Order Quantity Model for Time Varying Demand', *International journal of modern engineering*, Volume 1, Number 2
- [2] Coyle JJ, Bardi EJ, Langley CJ Jr, 2003, 'The Management of Business Logistics', Seventh Edition, Thomson
- [3] Jacobs FR, Chase RB, Aquilano NJ, 2009, 'Operations and Supply Management', Twelfth Edition, McGraw Hill
- [4] Porter AL, Roper AT, Mason TW, Rossini FA, Banks J, 1991, 'Forecasting and Management of Technology', John Wiley & Sons, pp191- 92
- [5] Rowbotham F, Galloway L, Azhashemi M, 2007, 'Operations Management in context', Second Edition, Butterworth-Heinemann
- [6] Salvendy G, 1992, 'Handbook of Industrial Engineering' Second Edition, Institute of industrial engineers
- [7] Walonick DS, 1993, 'An Overview of Forecasting Methodology'
- [8] Winston WL, 2004, 'Introduction to Probability Models', Fourth Edition, Thomson
- [9] Web Available <<http://www.wildflavors.com>>
- [10] Waters CDJ, 1992, 'Inventory Control and Management', Wiley

## Appendix A

### Calculations for 500ml bottles

<i>Product</i>	<i>D(to)</i>	<i>Average demand for x months</i>	$\alpha$	<i>Holding cost</i>	<i>Ordering Cost</i>	<i>bn</i>	<i>EOQ</i>
<i>500ml</i>	50489	43245	0.009267	0.2	2435	0.006436	35176
	49540	43245	0.009267	0.2	2435	0.006429	34478
	44352	43245	0.009267	0.2	2435	0.00649	31163
	39926	43245	0.009267	0.2	2435	0.006869	29697
	34529	43245	0.009267	0.2	2435	0.007238	27066
	30863	43245	0.009267	0.2	2435	0.007792	26051
	28985	43245	0.009267	0.2	2435	0.008232	25854
	27027	43245	0.009267	0.2	2435	0.008486	24853
	38374	43245	0.009267	0.2	2435	0.008788	36553
	41300	43245	0.009267	0.2	2435	0.007487	33494
	53334	43245	0.009267	0.2	2435	0.007117	41106
	57734	43245	0.009267	0.2	2435	0.006307	39420
	56428	43245	0.009267	0.2	2435	0.006019	36762
	53736	43245	0.009267	0.2	2435	0.006082	35373
	51276	43245	0.009267	0.2	2435	0.006234	34599
	45446	43245	0.009267	0.2	2435	0.006381	31393
	44806	43245	0.009267	0.2	2435	0.006788	32931
	36895	43245	0.009267	0.2	2435	0.006824	27261
	37762	43245	0.009267	0.2	2435	0.007555	30900
	42107	43245	0.009267	0.2	2435	0.007433	33901
<b>Average EOQ</b>							<b>32402</b>

**Table 2: Exponential EOQ model for 500ml bottles**

<i>Product</i>	<i>Demand</i>	<i>Holding cost</i>	<i>Ordering Cost</i>	<i>EOQ</i>
<i>500ml</i>	50489	0.2	2435	35063
	49540	0.2	2435	34732
	44352	0.2	2435	32863
	39926	0.2	2435	31180
	34529	0.2	2435	28996
	30863	0.2	2435	27414
	28985	0.2	2435	26567
	27027	0.2	2435	25654
	38374	0.2	2435	30568
	41300	0.2	2435	31712
	53334	0.2	2435	36037
	57734	0.2	2435	37494
	56428	0.2	2435	37068
	53736	0.2	2435	36173
	51276	0.2	2435	35335
	45446	0.2	2435	33266
	44806	0.2	2435	33031
	36895	0.2	2435	29973
	37762	0.2	2435	30323
	42107	0.2	2435	32020
			<b>Average EOQ</b>	<b>32273</b>

**Table 3: Basic EOQ model for 500ml bottles**

## Appendix B

### Calculations for 330ml bottles

<i>Product</i>	<i>D(to)</i>	<i>Average demand for x months</i>	$\alpha$	<i>Holding cost</i>	<i>Ordering Cost</i>	<i>bn</i>	<i>EOQ</i>
330ml	7328	6347	0.0186	0.8	1284	0.01231	4880
	7002	6347	0.0186	0.8	1284	0.01229	4653
	6268	6347	0.0186	0.8	1284	0.01257	4263
	5284	6347	0.0186	0.8	1284	0.0133	3804
	4362	6347	0.0186	0.8	1284	0.01451	3428
	3721	6347	0.0186	0.8	1284	0.01598	3223
	3954	6347	0.0186	0.8	1284	0.01727	3704
	3758	6347	0.0186	0.8	1284	0.01672	3407
	5692	6347	0.0186	0.8	1284	0.01715	5292
	8696	6347	0.0186	0.8	1284	0.01424	6704
	9565	6347	0.0186	0.8	1284	0.01159	5994
	9180	6347	0.0186	0.8	1284	0.01079	5352
	9990	6347	0.0186	0.8	1284	0.01098	5930
	8100	6347	0.0186	0.8	1284	0.01053	4612
	7425	6347	0.0186	0.8	1284	0.01175	4718
	6750	6347	0.0186	0.8	1284	0.01221	4460
	5481	6347	0.0186	0.8	1284	0.01281	3800
	4536	6347	0.0186	0.8	1284	0.01428	3507
	4928	6347	0.0186	0.8	1284	0.01567	4184
	4914	6347	0.0186	0.8	1284	0.01499	3990
<b>Average EOQ</b>							<b>4495</b>

**Table 4: Exponential EOQ model for 330ml bottles**

<i>Product</i>	<i>Demand</i>	<i>Holding cost</i>	<i>Ordering Cost</i>	<i>EOQ</i>
<i>330 ml</i>	7328	0.8	1284	4850
	7002	0.8	1284	4741
	6268	0.8	1284	4486
	5284	0.8	1284	4118
	4362	0.8	1284	3742
	3721	0.8	1284	3456
	3954	0.8	1284	3563
	3758	0.8	1284	3473
	5692	0.8	1284	4274
	8696	0.8	1284	5283
	9565	0.8	1284	5541
	9180	0.8	1284	5428
	9990	0.8	1284	5663
	8100	0.8	1284	5099
	7425	0.8	1284	4882
	6750	0.8	1284	4655
	5481	0.8	1284	4195
	4536	0.8	1284	3816
	4928	0.8	1284	3977
	4914	0.8	1284	3972
<b>Average EOQ</b>				<b>4461</b>

**Table 5: Basic EOQ model for 330ml bottles**

## Appendix C

### Calculations for 1.5L bottles

Product	D(to)	Average demand for x months	$\alpha$	Holding cost	Ordering Cost	bn	EOQ
1.5L	3019	3247	0.027718	1.1	1221	0.023768	2620
	2894	3247	0.027718	1.1	1221	0.023674	2501
	2373	3247	0.027718	1.1	1221	0.024186	2096
	2325	3247	0.027718	1.1	1221	0.026824	2280
	1772	3247	0.027718	1.1	1221	0.026963	1747
	2011	3247	0.027718	1.1	1221	0.031151	2295
	2364	3247	0.027718	1.1	1221	0.02906	2515
	2791	3247	0.027718	1.1	1221	0.026833	2738
	4094	3247	0.027718	1.1	1221	0.024713	3696
	4734	3247	0.027718	1.1	1221	0.020733	3578
	4858	3247	0.027718	1.1	1221	0.019002	3362
	4278	3247	0.027718	1.1	1221	0.018683	2910
	4632	3247	0.027718	1.1	1221	0.019942	3366
	3889	3247	0.027718	1.1	1221	0.019144	2712
	3973	3247	0.027718	1.1	1221	0.020948	3034
	3505	3247	0.027718	1.1	1221	0.020651	2639
	3000	3247	0.027718	1.1	1221	0.022022	2410
	2367	3247	0.027718	1.1	1221	0.023819	2058
	2722	3247	0.027718	1.1	1221	0.026904	2678
	3344	3247	0.027718	1.1	1221	0.025	3054
<b>Average EOQ</b>							<b>2714</b>

Table 6: Exponential EOQ model for 1.5L bottles

<i>Product</i>	<i>Demand</i>	<i>Holding cost</i>	<i>Ordering Cost</i>	<i>EOQ</i>
<i>1.5L</i>	3019	1.1	1221	2589
	2894	1.1	1221	2535
	2373	1.1	1221	2295
	2325	1.1	1221	2272
	1772	1.1	1221	1983
	2011	1.1	1221	2113
	2364	1.1	1221	2291
	2791	1.1	1221	2489
	4094	1.1	1221	3015
	4734	1.1	1221	3242
	4858	1.1	1221	3284
	4278	1.1	1221	3082
	4632	1.1	1221	3207
	3889	1.1	1221	2938
	3973	1.1	1221	2970
	3505	1.1	1221	2789
	3000	1.1	1221	2581
	2367	1.1	1221	2292
	2722	1.1	1221	2458
	3344	1.1	1221	2725
<b>Average EOQ</b>				<b>2657</b>

**Table 7: Basic EOQ model for 1.5L bottles**

## Appendix D



**Figure 6: Different quantities sold by Oasis**



**Figure 7: Bottles in packaging**