WAREHOUSE LOGISTICS OPTIMIZATION

FINAL PROJECT REPORT

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SIMULATION MODELING

"On my honor, I have neither given nor received unauthorized aid in completing this academic work."

Signature:

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ABSTRACT:

This is a model of a small business which operates from a warehouse. The warehouse is divided into several zones and has several staff types. The entire process runs in two different flows – Loading flow & Unloading flow. In the loading flow, Orders are being received by the warehouse. For each order forklift picks a single product from the storage and transports it to a Dispatch area. In this area controlling staff matches the product contents with the order. After the number of orders reaches the capacity, a retail truck drives into the warehouse and takes the products out of the warehouse. In the unloading flow, the products are delivered to the warehouse by supply trucks. Then servicing staff unloads and transports the products to the Reception zone. Products are handled, marked by registrars and then are moved to the Storage zone with forklift trucks and stacked up with overhead crane.

BACKGROUND:

Two recently graduated students from Carl H Lindner Business School want to start a small business operating from a warehouse. Idea of the business is to buy products from different small-time suppliers, put all the bought products in one common platform and sell them at some markup percentage. They know the different kind of resources required for the business. They also know the statistics for some of those resources. Before they go ahead with the business, they want to know the optimal number of resources required and some analysis on the pricing aspect.

PARAMETERS AND AVAILABLE DATA:

Warehouse Staff:

1. Unloaders: People who unloads the products from the supply truck
2. Registrars: People who checks and marks the products
3. Supply Transferrers: People who moves the handled products to storage zone
4. Acceptors: People who accepts the orders and manages the process. Required number of acceptors is assumed to be 2
5. Order Transferrers: People who picks the ordered products from the storage and moves to control zone
6. Controllers: People who checks and matches the transferred products with orders
7. Loaders: People who moves the checked products from control zone to dispatch zone
8. Crane Operators: People who operates the overhead crane. This is estimated to be 1.

Transportation Resources:

1. Supply Trucks: Truck to get the products from the suppliers to the warehouse
2. Retail Trucks: Truck to deliver the products to the ordered customers
3. Forklifts: To move the product from one zone to another within the warehouse
4. Overhead cranes: To stack the product in top rows. Required number of overhead cranes is estimated to be 1

Initial Setup costs:

1. Construction cost - $800,000
2. Cost for each supply truck - $125,000

3. Cost for each retail truck - $80,000
4. Cost for each forklift - $15,000
5. Cost for each overhead crane - $10,000

Recurring Costs:

1. Average hourly wage of warehouse staff - $10
2. Operations cost - $1,200,000
3. Land Lease - $1,500,000
4. Buying cost per unit(supply) - $200
5. Selling price per unit - $300 (For markup percentage = 50%)

Inter arrival time of orders:

1. Interarrival time of orders are uniformly distributed between 2min and 4min

Time required to process each unit:

1. Inter loading time for loaders - Uniformly distributed between 4min and 6min
2. Inter checking time for controllers - Uniformly distributed between 5min and 8min
3. Inter transferring time for order transferrers - Uniformly distributed between 5min and 12min
4. Inter unloading time for unloaders - Uniformly distributed between 3min and 5min
5. Inter handling time for registrars - Uniformly distributed between 4min and 6min
6. Inter transferring time for supply transferrers - Uniformly distributed between 5min and 8min

Inter arrival times of trucks:

1. Inter arrival time for retail truck
2. Inter arrival time for supply truck - Uniformly distributed between 100min and 120min

Return time of trucks:

1. Supply truck return time - Uniformly distributed between 180min and 240min
2. Retail truck return time - Uniformly distributed between 220min and 240min

Capacity:

1. Supply truck capacity – 60 products
2. Retail truck capacity – 20 products
3. Forklift capacity – 1 product
4. Each order capacity – 1 product

ASSUMPTIONS:

- Different kind of products being sold in this business are similar.
- So, buying cost, selling price and demand of all the products is taken as constant
- All the inter arrival times/inter working times are taken as uniformly distributed considering above assumptions

BUSINESS FLOW:

First, for this business to run successfully warehouse should be divided into different zones to run each job systematically. As there are 6 major things in the entire business flow, warehouse is divided into 6 zones.

WAREHOUSE LAYOUT:

1. Unloading zone: This is the zone where the supplied products are unloaded from the supply trucks
2. Reception zone: This is zone where supplied products are queued to move to the storage area
3. Storage zone: This is the storage area where all the supplied products are stored
4. Service zone: In this zone acceptors accepts and manages the incoming orders
5. Control zone: In this zone the product is checked and matched with the order
6. Dispatch zone: This is the loading zone where the ordered product is loaded into the retail truck to dispatch.

ORDER LOAD FLOW:

This is one of the two main flows in this business. This is about the process of receiving and delivering an order.

Service Zone	• Acceptors accepts an order • Passes the information to order transferrers • Updates the inventory
Storage Zone	• Transferrers picks up the ordered product from the storage zone with the help of crane • Moves the order to control zone
Control Zone	• Controllers in the control zone checks and matches the transferred product with the order
Dispatch zone	•Loaders picks up the matched product from the control zone and moves it to dispatch zone to load it into a retail truck

SUPPLY UNLOAD FLOW:

This is the other main flow in this business. This is about the process of receiving and storing the supplied products.

Unloading zone	•Unloaders unloads the supply products from the supply truck •Transfers the products to the reception zone
Reception Zone	•Registrars in the reception zone checks and handles the products •Updates the inventory data
Storage Zone	•Supply Transferrers picks up the handled product from reception zone, moves it to storage area and stacks up the product with the help of over head crane

PURPOSE:

Purpose of this analysis is to find optimal number of resources required for this business using simulation i.e., to find the optimal number of required retail trucks, supply trucks, Forklifts, All types of warehouse staff.

CALCULATE OPTIMAL VALUES:

Used simulation to calculate each of the required parameters.

RETAIL TRUCKS:

As the capacity of a retail truck is 20, order queue capacity is taken as 20.

Generated 20 orders with the given interarrival time of orders and calculated total time taken to receive 20 orders.

Using monte carlo simulation, generated 1000 values for total time taken to receive 20 orders and calculated average of all those values.

Using the average of 1000 values of total time taken to receive 20 orders and maximum time taken for a retail truck to return from delivering the products, calculated number of retail trucks required so that the delivery will not be delayed.

From the above analysis, ***number of required retail trucks = 5***

Based on the average time taken to receive 20 orders, ***Interarrival time of retail truck is estimated as uniformly distributed between 50min to 60min***

SUPPLY TRUCKS:

As the capacity of a supply truck is 60, generated 60 orders with the given interarrival time of orders and calculated total time taken to receive 60 orders.

Using monte carlo simulation, generated 1000 values for total time taken to receive 60 orders and calculated average of all those values.

Using the average of 1000 values of total time taken to receive 60 orders and maximum time taken for a supply truck to return with from the suppliers, calculated number of supply trucks required so that there won't be a state where products are not available when an order is received.

From the above analysis, ***number of required supply trucks = 2***

SUPPLY QUANTITY:

In the above simulation, average total time taken to receive 60 orders is calculated.

Total working time of the warehouse per day is assumed to be 600min i.e., 10 Hours.

Using above two values, average number of orders received in a day is calculated as around 200.

As two supply trucks are available and atleast 200 products are required in a day, each truck should run for 2 times which means maximum of 240 units of the product can be supplied (supply truck capacity is 60) in a day.

But as the average number of orders received in a day is expected to be 200, ***number of units of the product to be supplied in a day is set as 210*** so that there won't be a lot of extra units in the warehouse.

LOADING FLOW STAFF:

Staff required in the loading flow are: Acceptors, Loaders, Controllers & Order Transferrers.

Given that, Inter loading time for loaders is uniformly distributed between 4min and 6min

Inter checking time for controllers is uniformly distributed between 5min and 8min

Inter transferring time for order transferrers is uniformly distributed between 5min and 12min

Required number of acceptors is assumed to be 2

Interarrival time of retail truck is uniformly distributed between 50min and 60min

As the order queue capacity is taken as 20, generated inter loading time, inter checking time and inter transferring time for 20 orders and calculated total time taken for each task.

Using monte carlo simulation, generated 1000 values for time taken to complete each of the three tasks for 20 orders and calculated average for each category.

Using the average values from above and minimum value in the interarrival time range for a retail truck, calculated number of loaders, controllers and order transferrers required so that the delivery will not be delayed.

From the above analysis, number of required ***loaders = 3,*** number of required ***controllers = 3*** and number of required ***order transferrers = 4***

UNLOADING FLOW STAFF:

Staff required in the loading flow are: Unloaders, Registrars & Supply Transferrers.

Given that, Inter loading time for unloaders is uniformly distributed between 3min and 5min

Inter handling time for controllers is uniformly distributed between 4min and 6min

Inter transferring time for order transferrers is uniformly distributed between 5min and 8min

Interarrival time of retail truck is uniformly distributed between 100min and 120min

As the supply truck capacity is taken as 60, generated inter unloading time, inter handling time and inter transferring time for 60 units of the products and calculated total time taken for each task.

Using monte carlo simulation, generated 1000 values for time taken to complete each of the three tasks for 60 units and calculated average for each category.

Using the average values from above and minimum value in the interarrival time range for a supply truck, calculated number of unloaders, registrars and supply transferrers required so that the delivery will not be delayed.

From the above analysis, number of required ***unloaders = 3,*** number of required ***registrars = 3*** and number of required ***supply transferrers = 4***

PRICING ASPECT ANALYSIS:

Some extra analysis is done for this business model to understand the pricing aspect such as time required to get profits from the business, Profit gained in 15 years when demand and supply are kept to be constant and also cost sensitivity analysis for recurring costs.

YEARS TAKEN TO GET POSITIVE NET PRESENT VALUE:

Average working days in a year are assumed to be 260

Discount rate to calculate NPV is assumed to be 40%

With all the optimal values calculated above, given costs and assumed values, NPV is calculated for each year and checked if it is positive.

From the above analysis, NPV is positive from year 6 which means by end of year 6 initial set up cost for this business will be balanced.

NPV CALCULATION FOR 15 YEARS:

Following the same process as in the above analysis, expected NPV is calculated for 15 years which is around $431,566.46.

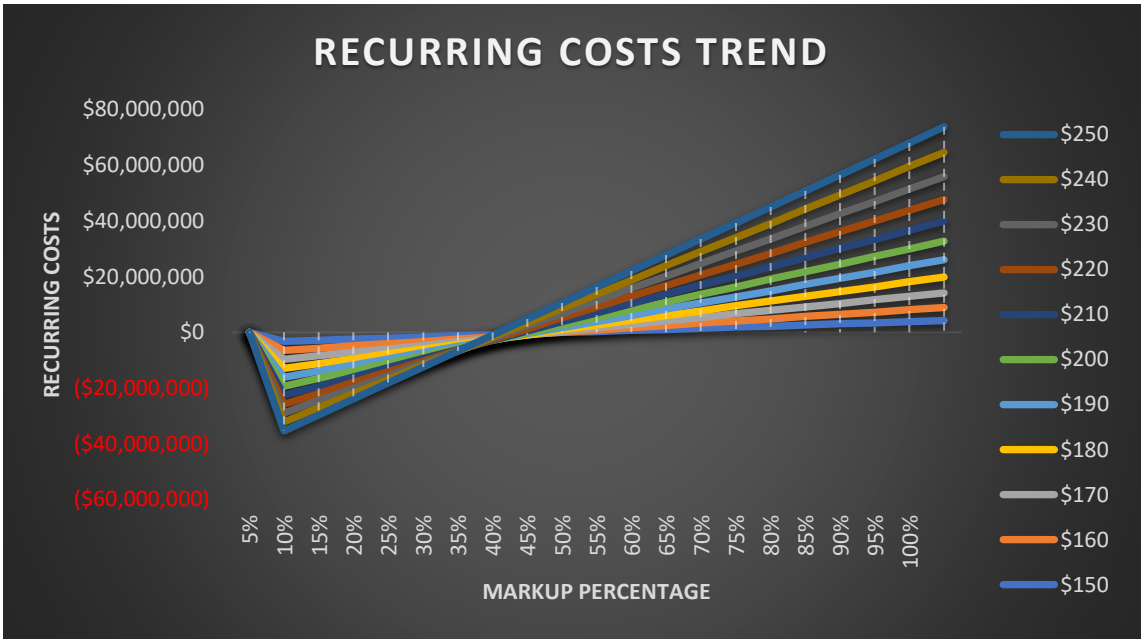
Here, supply and demand are assumed to be constant.

COST SENSITIVITY ANALYSIS:

- With all the optimal values calculated above, given costs and assumed values, recurring costs per annum is calculated. This value is for 50% markup percentage and $200 buying price for each unit of the product.
- With time and demand, buying price of the product and markup percentage might change. So, to check the sensitivity of recurring costs, recurring costs is calculated for different buying price ($150 to $250 with increment of $10) and different markup percentage (5% to 100% with increment of 5%).

Below is the cost sensitivity chart for recurring costs:

Chart 1: Cost sensitivity chart for recurring costs



Inference:

- For any buying price of the product, to get positive recurring costs markup percentage for selling price should be atleast 50%
- For the existing buying price of the product ($200), to get positive recurring costs markup percentage for selling price should be atleast 40%

CONCLUSION:

- Optimal resources for this business are as follows:

Table 1: Optimal warehouse staff required

Warehouse staff	
Unloaders	3
Registrars	3
Supply Transferrers	4
Acceptors	2
Order Transferrers	4
Controllers	3
Loaders	3
Crane Operators	1

Table 2: Optimal Transportation required

Transportation Parameters	
Retail Trucks	5
Supply Trucks	2
Forklifts	13
Cranes	1

- For the business to not incur any loss, it should run for atleast 6 years assuming other parameters stay constant
- For any buying price of the product, to get positive recurring costs markup percentage for selling price should be atleast 50%
- For the existing buying price of the product ($200), to get positive recurring costs markup percentage for selling price should be atleast 40%

APPENDIX:

Supporting Files:

Excel sheet: An excel sheet with all the simulations calculating optimal values for resources and additional analysis.

Basic warehouse model: Warehouse logistics information is referred from

Source: https://cloud.anylogic.com/model/4b6944d0-1426-4db4-a246-6f61ccc3c4a5?mode=SETTINGS&tab=GENERAL