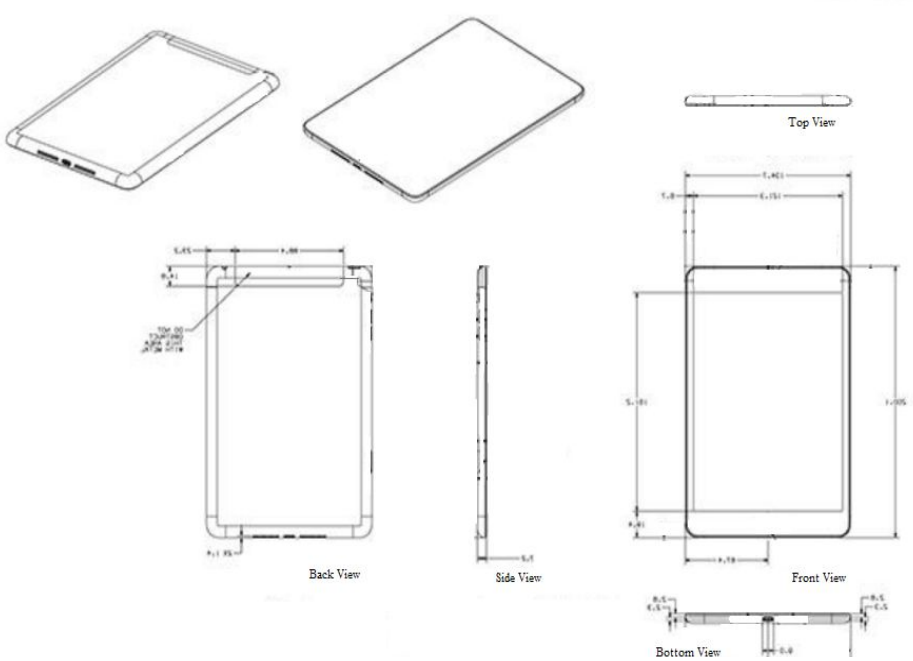
Text.book



Group 7:

Pranav Lodha
Lemuel Chan
Junyan Mak
Susana Esparza
Xiaochen Zhang
Eric Walker
Huiting Zhu

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Section 1.0: Introduction

1.1 Executive Summary

Our Mission:

University students typically spend as much as $1,200 a year total on textbooks (College Board). 65% of students say they have skipped buying a textbook because it was too expensive (U.S. Public Interest Research Group). We strive to provide an affordable electronic textbook alternative to all students by minimizing many of the distracting features in tablets today, stripping down our product to the bare minimum.

Our Supply Chain:

In order for Text to be successful, aside from a great business management strategy, a well implemented supply chain management is necessary. In this report Text.book focuses on the supply chain management of our product Text.book, an affordable electronic textbook alternative.

The importance of the supply chain management is high because the strategy we implement is necessary for the launch of our product to meet the demand of our consumers. It's crucial that our supply chain strategy is as responsive and effective as can be. In today's society people want easy and fast access to the products they consume at an affordable price and in order to achieve that our supply chain strategy needs to be well developed. We believe that Text.book's supply chain management is both responsive and effective after all the research we have done and the software we have created to help us with our demand forecasting, inventory management, facilities, and transportation.

Text.book believes that the supply chain management software we have created enables us to better supply our product Text.book in the present and in the future with the most minimal cost in the most responsive way to have our consumers satisfied.

1.2 Project Planning

a. Quarter Plan

TASK	DUE DATE
Form project teams and choose technology domain	01/09/18 (In class)
Project Proposal	01/11/18
Phase 1 (Technology/Product Strategy and SC Strategy/Design)	01//23/18
Phase 2 (Supply Chain modeling and planning; demand forecasting)	02/06/18
Phase 3 (Supply Chain operations: inventory, transportation, and facilities)	02/20/18
Phase 4 (The software information system for the Supply Chain; simulation)	03/06/18
Phase 5: Closure and Final Report	03/13/18

Figure 1: Key Dates to Submit the Phases for the Project

b. Project Plan

Members Tasks	**Pranav Lodha**	**Lemuel Chan**	**Junyan Mak**	**Susana Esparza**	**Xiaochen Zhang**	**Eric Walker**	**Huiting Zhu**
Firm-up the project proposal	X	X	**X**	X	X	X	X
Review problems on HW's 1 and 2	X	X	X	X	X	**X**	X

Supply Chain Strategy		X	X	X	**X**	X	
High-level structure(drivers) for Text.Book supply chain			**X**		X		
High-level plan for the software development			X	X	X		
Demand Data for the Text.Book	**X**					X	X
Cycle Inventory	X					**X**	
Safety Inventory	X					**X**	
Facilities			**X**				
Transportation			X				X
User Manual	X	X	**X**	X	X	X	X

Figure 1: Project Plan for the Team

Explanation: These are the roles of everyone in our project team. At our team meetings, we collaborate and split up the roles for efficiency, and then come back together to explain what we did to have a cohesive product.

1.3 Work Distribution Table

Tasks	Subtasks	Current Status	Work to be done		Who's responsible	When due?
			Models/Manual	Software		
					Primary:... Secondary...	
Strategy			NA	NA		
		Meeting with Sub	Holt's	Excel and Visual Basics	Pranav Lodha	2/26/18
		Meeting with Sub	Winter's	Excel and Visual Basics	Pranav Lodha	2/26/18
Forecasting						
		Meeting with Sub	N/A	Excel and Visual Basics	Eric Walker	3/5/18
					Junyan Mak	3/5/18
Inventory cycle						
		Meeting with Sub	N/A	Excel and Visual Basics	Eric Walker	3/5/18
					Xiaochen Zhang	
Inventory safety						
		Meeting with Subhas		Excel and Visual Basics	Junyan Mak	3/5/18
		Meeting with Subhas		Excel and Visual Basics	Lemuel Chan	3/5/18
Facilities						
		Meeting with Subhas		Excel and Visual Basics	Lemuel Chan	3/5/18
					Huiting Zhu	3/5/18
					Junyan Mak	3/5/18
Transportation						
		Meeting with Subhas		Excel and Visual Basics	Susana Esparza	3/5/18
					Huiting Zhu	
Integration					Xiaochen Zhang	
		Meeting with Subhas			Pranav Lodha	3/5/18
					Lemuel Chan	
					Junyan Mak	
Backlog						
		Inprogress			Xiaochen Zhang	3/19/18
					Pranav Lodha	
					Lemuel Chan	
					Junyan Mak	
					Susana Esparza	
					Huiting Zhu	
Final Report Compilation					Eric Walker	

Section 2.0 Supply Chain

2.1 Supply Chain

a. Dissect of Text.Book:

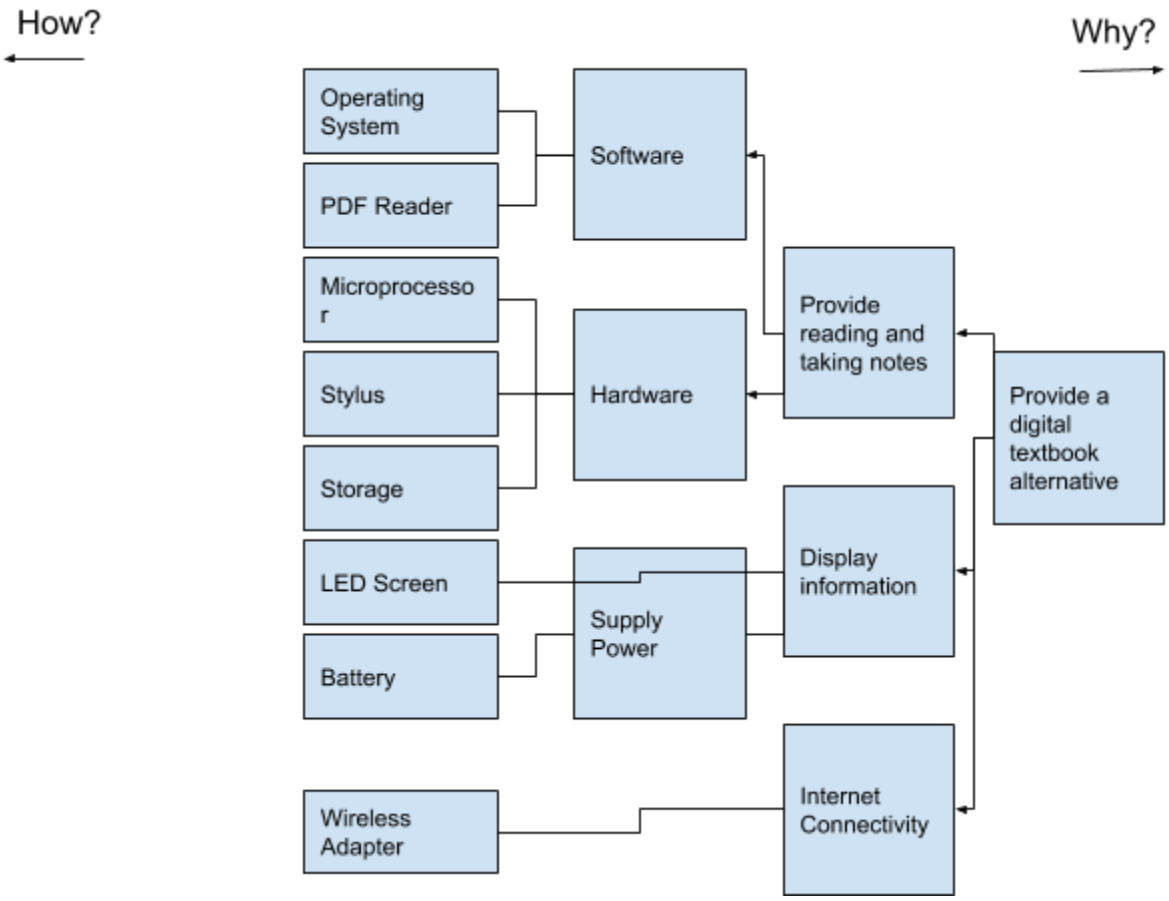


Figure 1: Fast Diagram for Text.Book

Explanation: By using the Fast Diagram, we are able to understand the subsystems needed and to figure out what is needed to be supplied for each subsystem.

b. Identify major subsystems and supplies:

i. Subsystems

1. Read PDF files
    a. Supply: Software
    b. Reason: Software will be the main component to read the PDF files for the students to read
2. Write on the Screen

a. Supply: Hard Tip Stylus
b. Reason: To take notes on PDF textbooks

3. Internet Connection
    a. Supply: Wireless Adapter
    b. Reason: To connect to the internet without the need for an ethernet adapter
4. Provide Power
    a. Supply: Lithium Battery
    b. Reason: Lithium Batteries are affordable

c. Develop the supply chain for the product

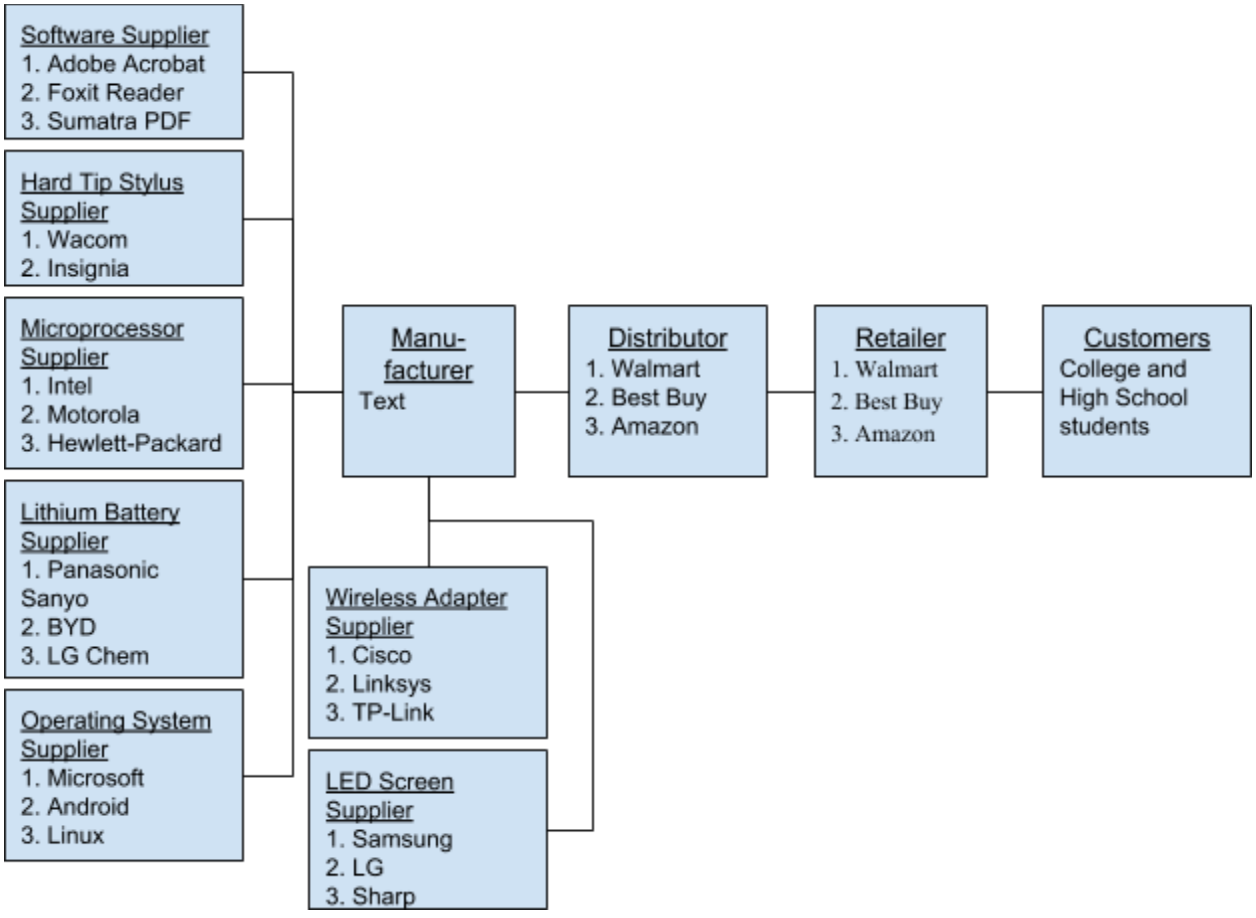


Figure 2: Supply Chain

Explanation: In this supply chain, we can see that starting from the right are the customers and targeted market are primarily students. Customers can buy our product from a retailer such as

Walmart, Best Buy, and Amazon. The manufacturer would be our company Text.book. We then pull the supplies for our product from several suppliers based on our listed subsystems above.

2.2 Supply Chain Network

d. Define the Cycles in the supply chain

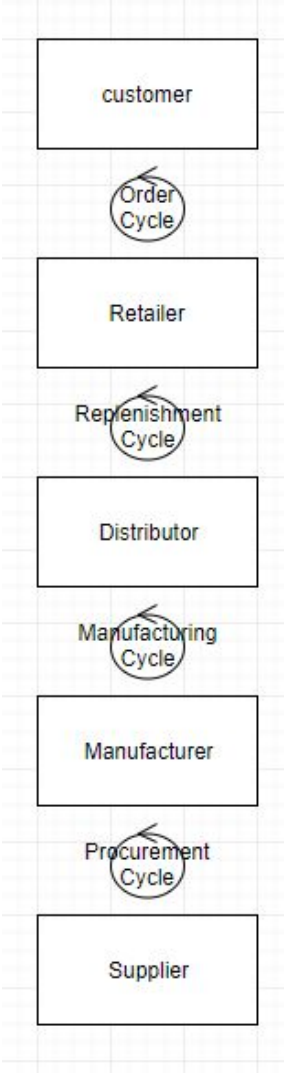


Figure 3: Cycles in the supply chain

Explanation: The cycles in the supply chain explain the operational cycles that occur between the two adjacent stages of the supply chain

Order Cycle: The customer will be ordering the Text.book product from our website or one of our many retailers

Replenishment Cycle: We will be replenishing the Text.book readers that have already been sold out so that we can continue to have the product in stock for everyone.

Manufacturing Cycle: In this cycle we will be putting together all the products so that we can send them to the retailer.

ProCurement cycle: In this cycle we will acquire all the parts that we need from our many suppliers that we can be using for to put together our product in the manufacturing cycle.

e. Identify the push and pull of the cycles

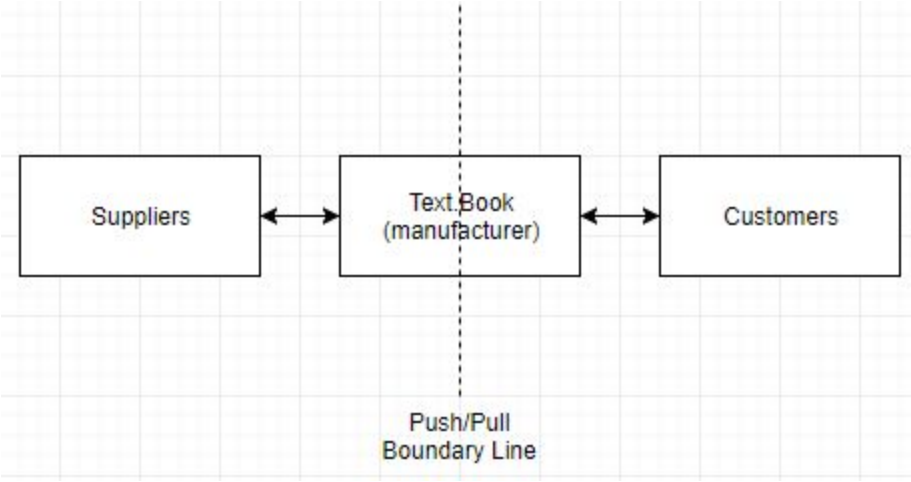


Figure 4: Push and Pull of Text.Book

Explanation: The Push cycle is initiated anticipation of customer demand and is more proactive. The Pull cycle is initiated by a request from the customer, and is reactive.

Push: The customer/ Retailer orders the product from us. We then would go and start building the product that we have.

Pull: The push is triggered by the pull of customers and retailers asking us for more of our product.

Modeled after Dell.

f. Define and understand the flow of the supply chain network

Figure 5: Flow of Information and Product in the Chain Networks

Explanation: Figure 5 describes what needs to flow through the chain which the Information system monitor.

g. Design the supply chain network

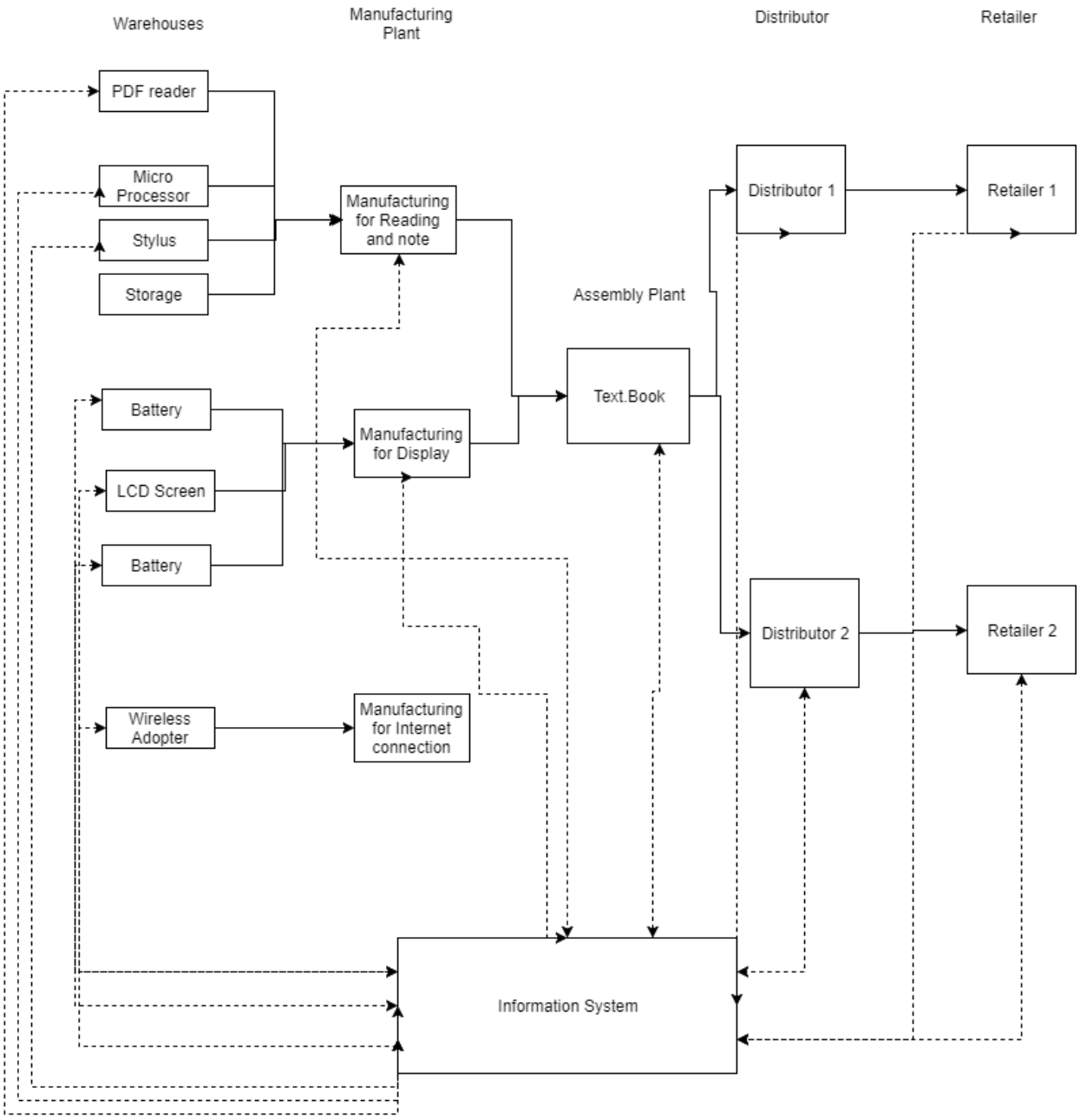


Figure 6: Supply Chain Network

Explanation: We can see the Figure 2 and Figure 5 look similar but the difference is how each warehouse, manufacturing plant, distributor and retailer are connected. Each link is connected by the Information System. The Information System allows cash flow, information and supplies to

go through the chain efficiently and effectively. The Information System eliminates misunderstands/confusions from each link in the chain.

Section 3.0 Financial Analysis

Define: update the financial model based on estimated historical demand data.

3.1 Product life-cycle model in the marketplace

- Introduction Stage: 1st year
    - In this stage we expect there to be lower sales volume due to the lack of popularity for our new product.
- Growth Stage: 2nd year
    - The growth stage of this product witnesses a faster rise in sales volume. However, this is not yet at the peak of our sales as this is the point in time where our product is still gaining traction.
    - In our growth stage we expect our product to gain some market share and sales volume should be increased.
- Maturity Stage: 3rd year
    - In this stage of the product life-cycle model, our product is experiencing the most amount of sales it will have, as it has become dominant in the marketplace.
    - In the maturity stage we expect our product to plateau in regards to sales since the market should be saturated with our product.
- Decline Stage: After 3rd year
    - In the decline stage our sales volumes are expected to decrease as the market becomes fully saturated with our product.
    - We assume at this stage the market has saturated. There will be many new entrants entry the market with new product, and competitor will publish similar products

3.2 Market analysis

i. The average student spending for a semester of course material is $509
ii. The percent of students who says they have skipped buying a textbook because it was too expensive is around 65%
iii. Average college bookstore profit margin for a new book is 21.1%

iv. Percent of students who buy their books at their college bookstore is 47%

v. The Average price of New Textbook and Average Price of Used Textbook:

	New	Used
2002	$42	$36
2007	$56	$50
2013	$69	$54
2015	$72	$58

3.3 Data Source

- https://www.statista.com/statistics/272070/global-tablet-shipments-by-quarter/
- For our Data we used the following link above to determine the what the approximate volume for our sales of our table would be. The link above provided us with worldwide tablet sales from the second quarter of 2010 to the fourth quarter of 2017. We would then use this data to estimate the amount of sales we would have with our table in the second quarter of 2014 to the fourth quarter of 2016.
- Below is our cash flow analysis which shows the excel spreadsheet screenshot of our calculations.

3.4 Cash flow analysis

Figure 3.4.1: Based Case Cash Flow

Base Case																
	Year 1				Year 2				Year 3				Year 4			
period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
($ values in thousands)	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2		
Development Cost	-3750.00	-3750.00	-3750.00	-3750.00												
Ramp-up cost				-1250.00	-1250.00											
Marketing & support cost					-600.00	-600.00	-600.00	-600.00	-600.00	-600.00	-600.00	-600.00	-600.00	-600.00	-600.00	-600.00
Production cost						-22280.00	-30560.00	-18560.00	-17640.00	-20200.00	-26480.00	-15840.00	-15720.00	-17200.00	-21160.00	-14480.00
Production volume						557000	764000	464000	441000	505000	662000	396000	393000	430000	529000	362000
Unit production cost						-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04
Sales Revenue						41775.00	57300.00	34800.00	33075.00	37875.00	49650.00	29700.00	29475.00	32250.00	39675.00	27150.00
Sales volume						557000	764000	464000	441000	505000	662000	396000	393000	430000	529000	362000
Unit price						0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Period Cash Flow	-3750.00	-3750.00	-3750.00	-5000.00	-1850.00	18895.00	26140.00	15640.00	14835.00	17075.00	22570.00	13260.00	13155.00	14450.00	17915.00	12070.00
PV Year 1,r-10%	-3750.00	-3658.54	-3569.30	-4643.00	-1676.01	16700.43	22540.44	13157.39	12175.78	13672.44	17631.65	10106.04	9781.48	10482.32	12678.93	8333.92
Project NPV,$	129,964															

Explanation: Based on our original calculations we would have a profit of approximately $12,567,000. But using the new data that we had gained from our source, https://www.statista.com/statistics/272070/global-tablet-shipments-by-quarter/, our new estimated profit would be approximately **$129,964,000.** The reason for this is because using our new historical data we are able to predict that our demand for our product will actually be about four and a half time larger than what we had initially expected.

Section 4.0 Supply Chain Strategy

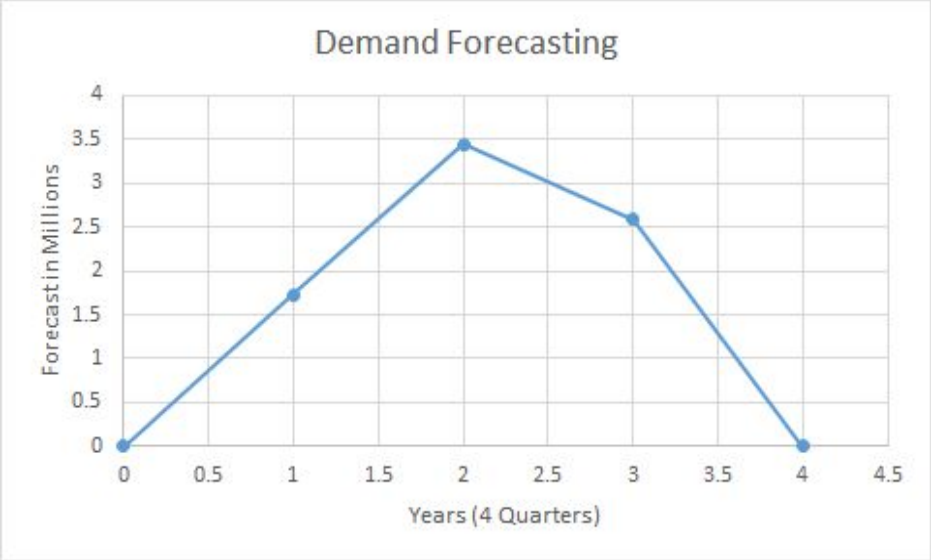
4.1 Understand customer needs:

Customer Needs
Light Weight
Long Battery Life
Stylus - dexterity
Simple User Design
High Brightness Spectrum

Explanation: Based off of our product development done in TIM 105, we have determined the customer needs to have the following attributes in the e-reader: lightweight, long battery life, a stylus, simple user design, and a high brightness spectrum.

4.2 Determine where the product lies in its market life-cycle

Figure 4.2.1: Product Life-cycle in the Market



Explanation: The stages of the product life cycle are listed below for the four years.

Quarter 0 to 4(Year 1): Introduction (Building Period)

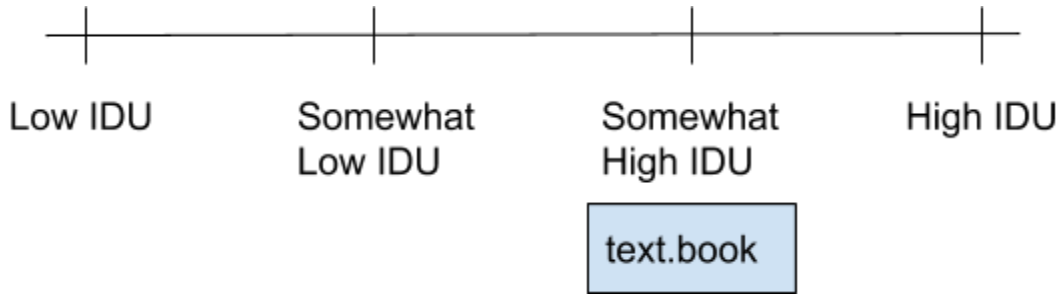
Quarter 4 to 8(Year 2): Growth

Quarter 8 to 12(Year 3): Maturity

Quarter 12 to 16(Year 4): Decline

4.3 Determine the IDU for the product & place it on the IDU spectrum

Figure 4.3.1: IDU Spectrum

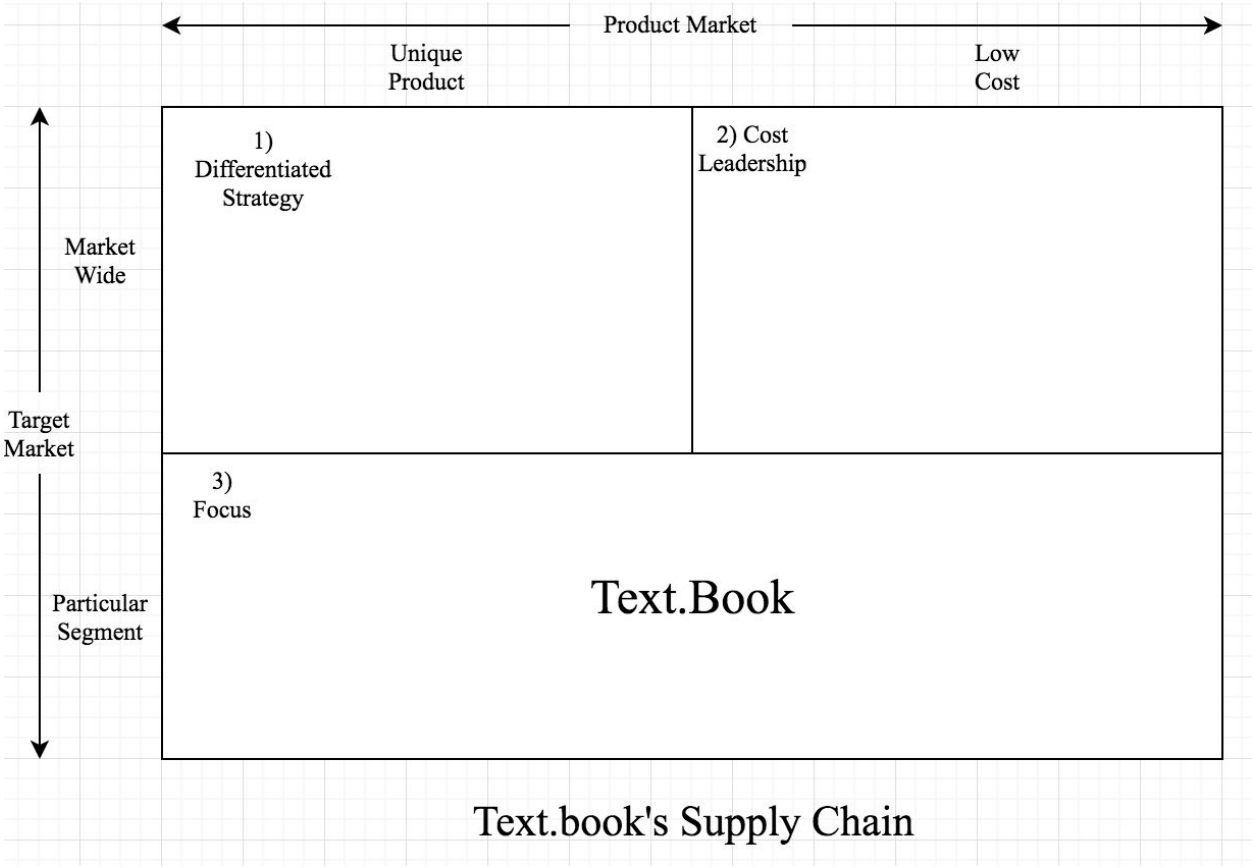


Explanation: Our implied demand uncertainty in the nominal quantity of products that are demanded by the customer will be on the somewhat high side of the spectrum

4.4 For the given product establish the corresponding competitive strategy:

i. Our product's (Text.book) defining features involve being the cheapest option for textbooks for everyone as well as being the newest product on the market. Therefore, our product falls into the Focus section of the competitive strategy, as we have the newest product, and a particular segment of the market (students and teachers/professors) to buy our ereader.

Figure 4.4.1: Competitive strategy

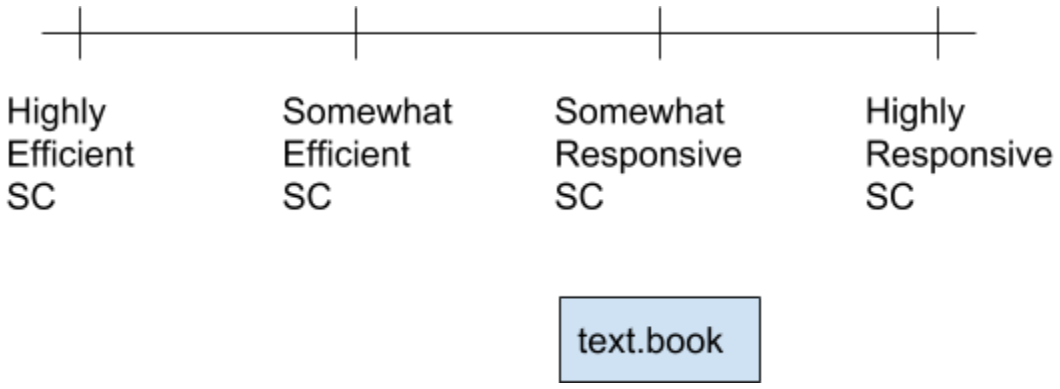


b. Determine the trade-off between responsiveness and efficiency for the product based on the competitive strategy.

i. According to our competitive strategy, our product is in somewhat responsiveness.

4.5 Map the resp/eff trade-off onto the resp/eff spectrum

Figure 4.5.1: Resp/eff Spectrum

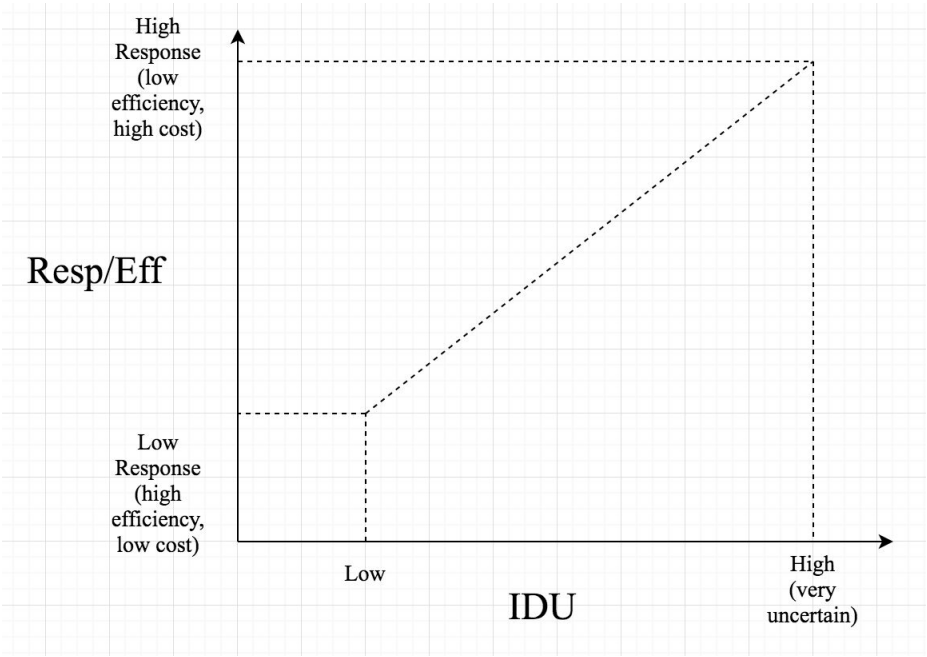


Explanation: Our product will be a Somewhat Responsive supply chain on the resp/eff spectrum, which basically means our supply chain will have the ability to respond rapidly to the following customer demands: a large range of products, large changes in quantity demanded, short lead times, and high service levels.

4.6 Supply Chain Strategy in zone of strategic fit

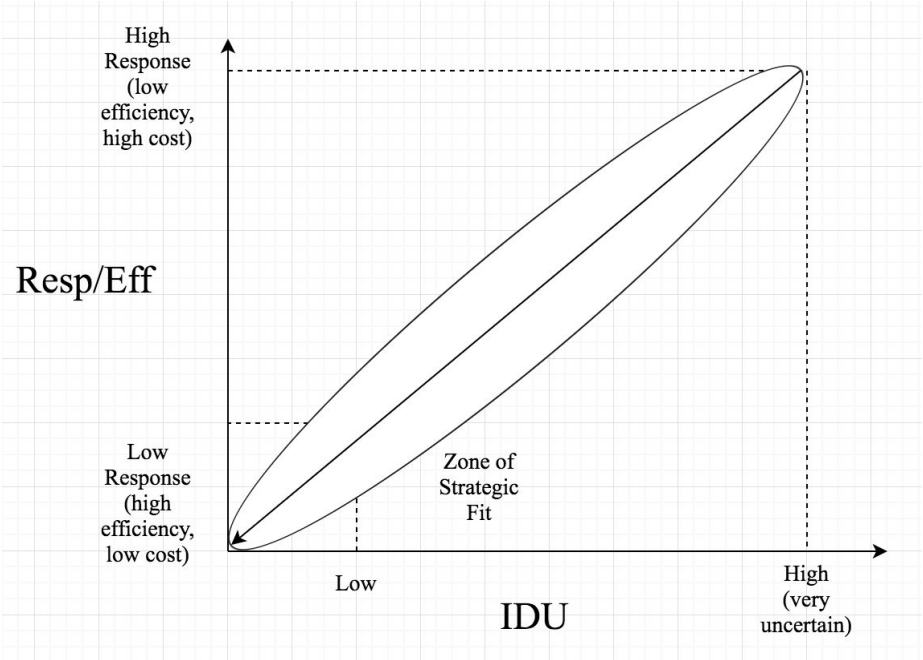
a. Create a 2-D space
    i. IDU spectrum is the x-axis(see below)
    ii. Resp/eff spectrum is the y-axis(see below)

Figure 4.6.1: 2-D Space



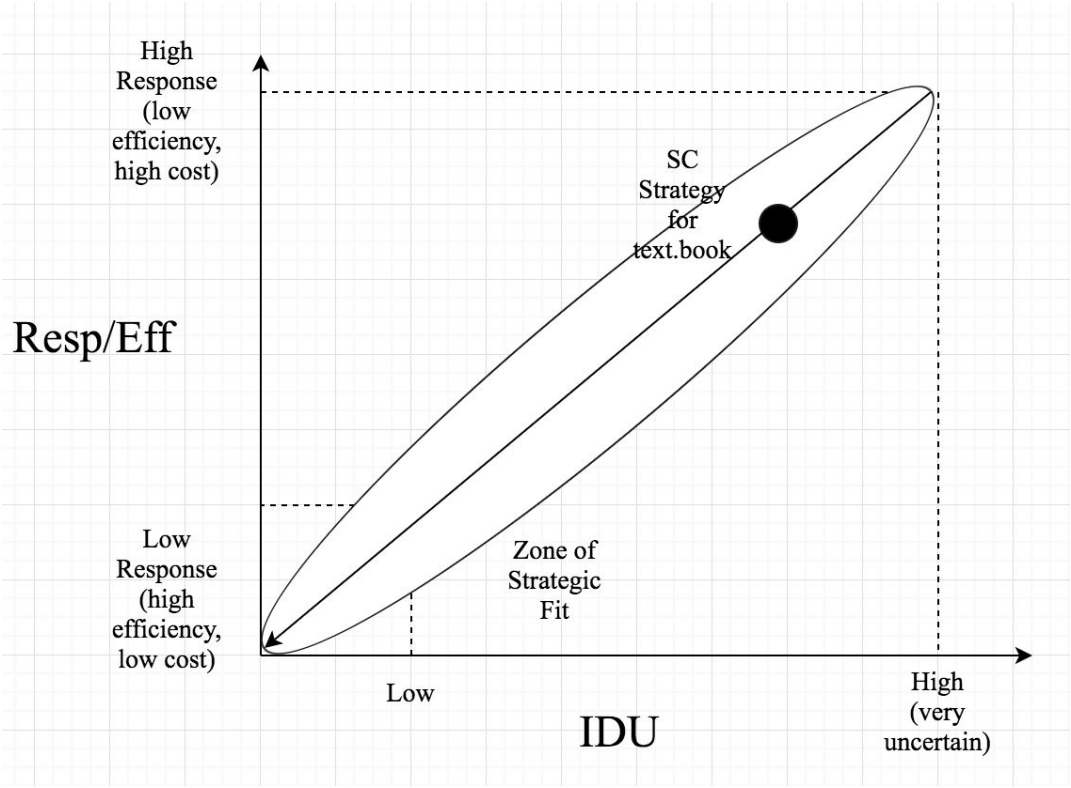
b. Define a zone of strategic fit in this 2-D space

Figure 4.6.2: Zone of Strategic Fit



c. Map the SC strategy for the product inside the zone of strategic fit.

Figure 4.6.3: Supply Chain Strategy



Explanation: Bringing the resp/eff and the IDU spectrum together brings us to a 2x2 grid for us to map Text.book's zone of strategic fit, and can allow us to expand upon our zone of strategic fit later to match our company goals.

Section 5.0 Beer Game

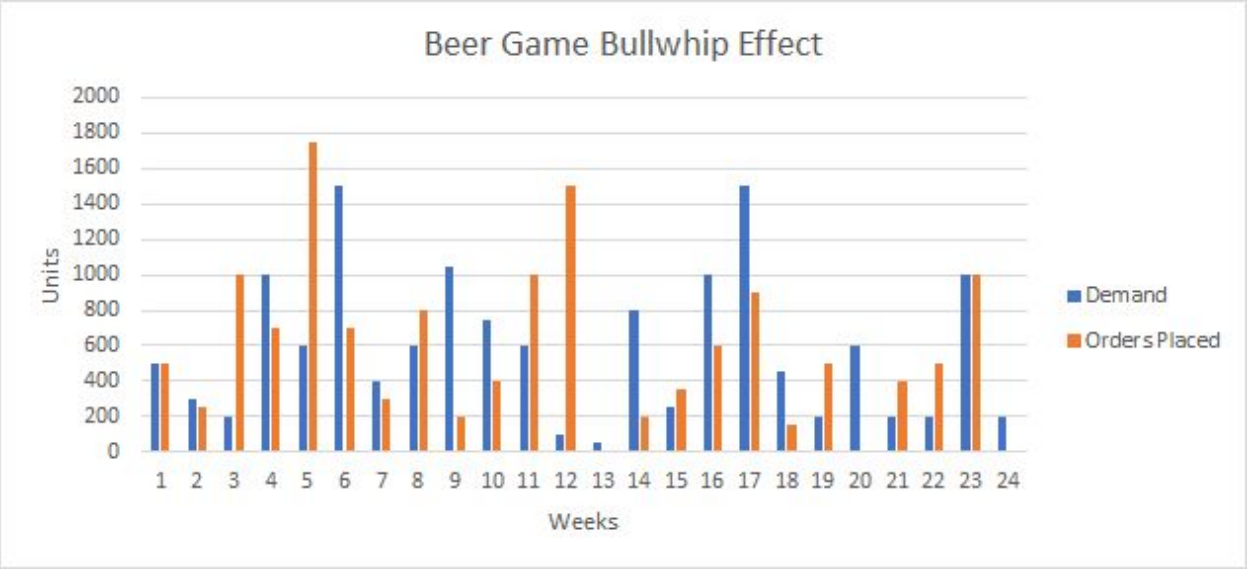
The beer game showed us how inefficient a supply chain could be without communication. For our project, we based our game on something similar to the example given to use. We ordered our parts from a supplier prematurely and then sent out our products based on the demand period of the customers. What we noticed was that the demand for our product will always be changing so it is hard to predict so that's why we need a safety inventory. This was our data:

Figure 1: Beer game score sheet

	A	B	C	D	E	F	G
1	current demand period	gross demand	amount shipped	ending inventory	backlog	place ordered	inventory
2	500						
3	300	300	300	200	0	500	700
4	200	500	200	500	0	250	750
5	1000	1500	750	0	250	1000	1000
6	600	2100	850	150	0	700	850
7	1500	3600	1500	-650	0	1750	1100
8	400	4000	400	700	0	700	1400
9	600	4600	600	800	0	300	1100
10	1050	5650	1050	50	0	800	850
11	750	6400	750	100	0	200	300
12	600	7000	300	0	300	400	400
13	100	7100	400	0	0	1000	1000
14	50	7150	50	950	0	1500	2450
15	800	7950	800	1650	0	0	1650
16	250	8200	250	1400	0	200	1600
17	1000	9200	1000	600	0	350	950
18	1500	10700	950	0	550	600	600
19	450	11150	600	0	400	900	900
20	200	11350	600	300	0	150	450
21	600	11950	450	0	150	500	500
22	200	12150	350	150	0	0	150
23	200	12350	150	0	50	400	400
24	1000	13350	400	0	600	500	500
25	200	13550	500	0	0	1000	1000

The current demand period was what the customers wanted during that period. Gross demand was just the sum all of all the demands. Amount shipped is the amount that we shipped out, either the entire order or our entire inventory in the case we didn't have enough. Ending inventory was how much inventory we had left over when after we sent out our shipment. Backlog is when we didn't have enough inventory and had to order extra for the upcoming period.

After completing the game, we noticed how the bullwhip effect affected our supply chain. There was varying demands throughout the ordering period which led to inefficiency and surplus. In our supply chain the varying demands and order placed really messed up our inventory.



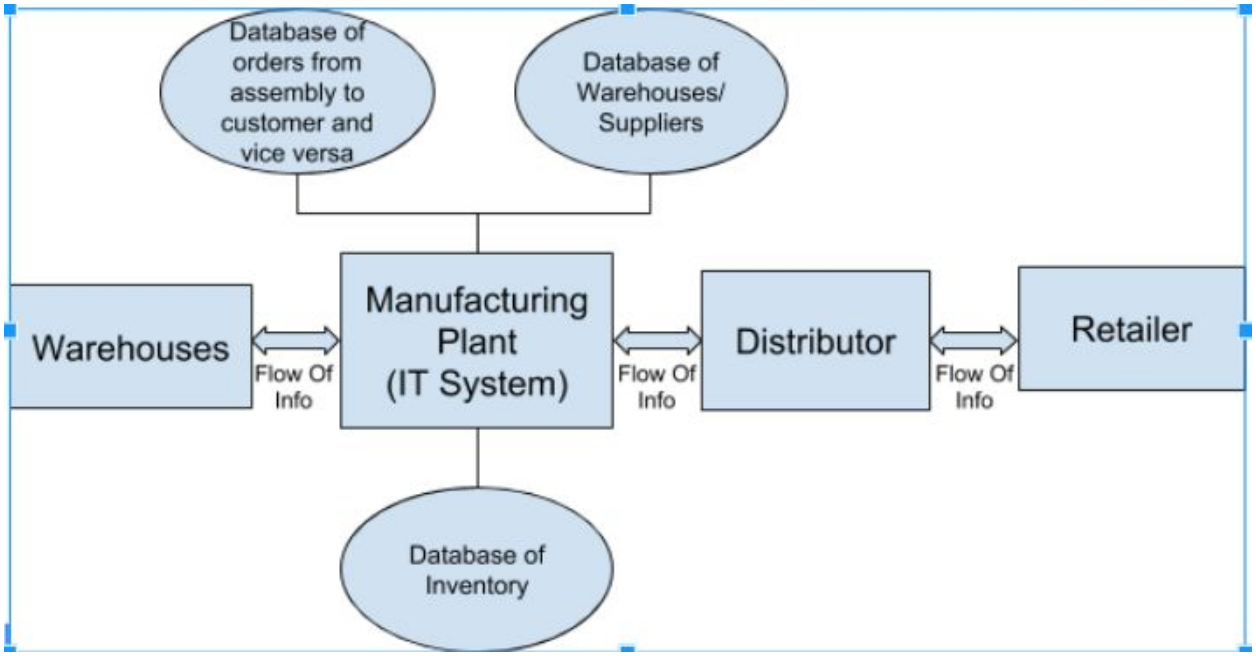
Section 6.0 High Level Plan for Software

6.1 Software Architecture outline

- Our software are using consulting services to build the product
- Then list consulting services:

1. OpenXcell
   - This consulting service has experience with iPad and IPhone which is very similar to our product.
2. Itransition
   - This consulting service has experience in making custom software for clients.
3. Orient Software
   - This consulting service is provides exceptional software outsourcing services.

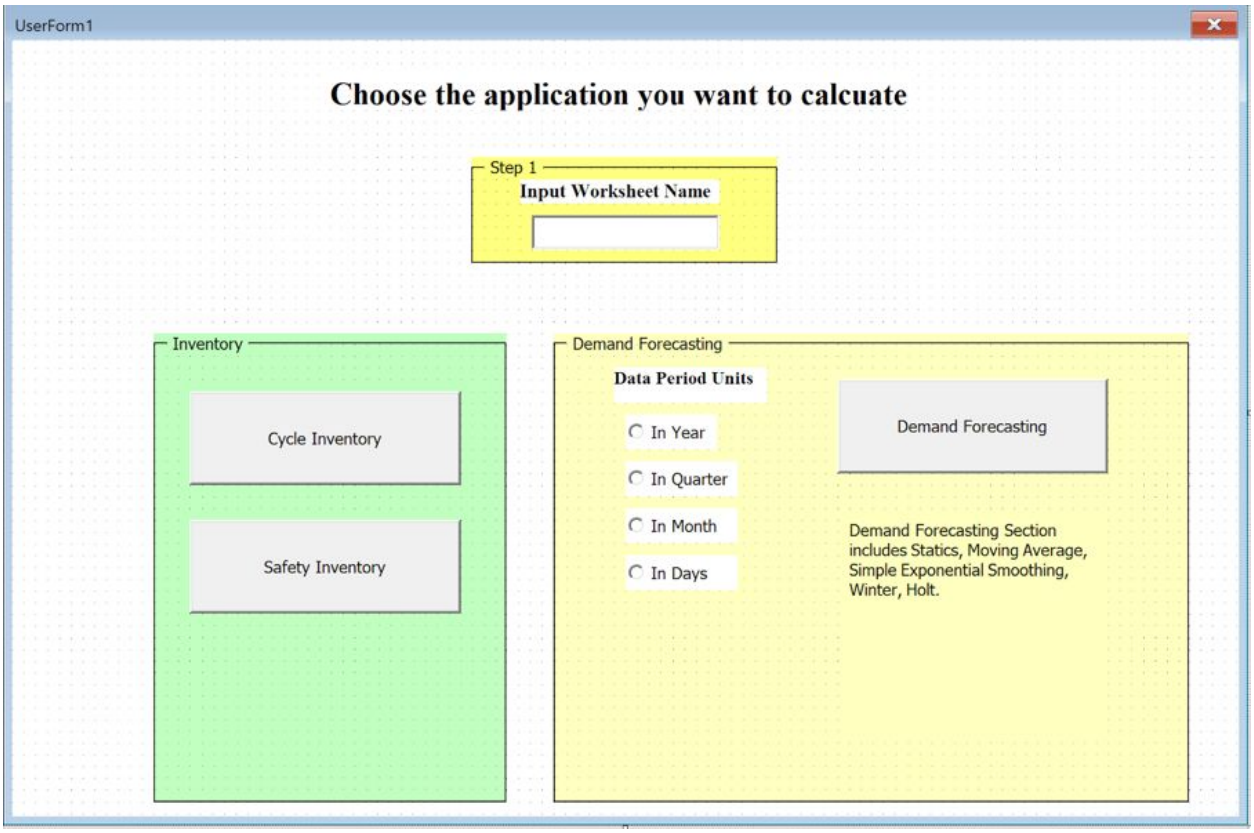
- Our software architecture must assess the following players
  - Warehouse
  - Manufacturing Plant (IT System)
    - Database of Inventory
  - Distributor
  - Retailer



6.2 Main page User Manual

- This program is like a organized main pages that allows users to choose which next program they want to choose. We have Inventory section and Demand Forecasting section.

Visual Basic P order to build the software architecture, the team will take the following steps to collectively build an IT system.



Step 1: Everyone download and get familiar with visual basic functions

Step 2: Explicitly define what needs to be done in terms of the software framework

Step 3: Designate roles to focus on those sub-sections of the software

Step 4: Report data rocess: Inback to the software so that management can oversee and review total progress of the sub-sections

6.3 General Overview

Overview of the Software Platform:

Three focal points of the IT System:

1. Track orders from the retailer and the orders filled for the retailer.
2. Track Inventory in warehouses, manufacturing plant and retailer.
3. Track warehouses and suppliers of the parts for the Text.book.

- Team steps to build the Software Architecture:

We have decided to go with Visual Basic for our software

1. Hold a day tutorial of how to use Visual Basic so the whole team is on the same page when it comes to Visual Basics
2. Another day to agree on the functions in Visual Basic that will be needed to for the IT system.
3. Have weekly reports from Visual Basic so we can adapt our strategies depending on the information.

- SCMS Functionality:
  - Customer requirement processing
  - Purchase order processing
  - Sales and distribution
  - Inventory management
  - Good receipt and warehouse management
  - Supplier management/sourcing

SCMS we also want to includes forecasting or such tools often attempt to balance the disparity between supply and demand by improving business processes and using algorithms and consumption analysis to better plan future needs. We also want to included integration technology that allows organizations to trade electronically with supply chain partners.

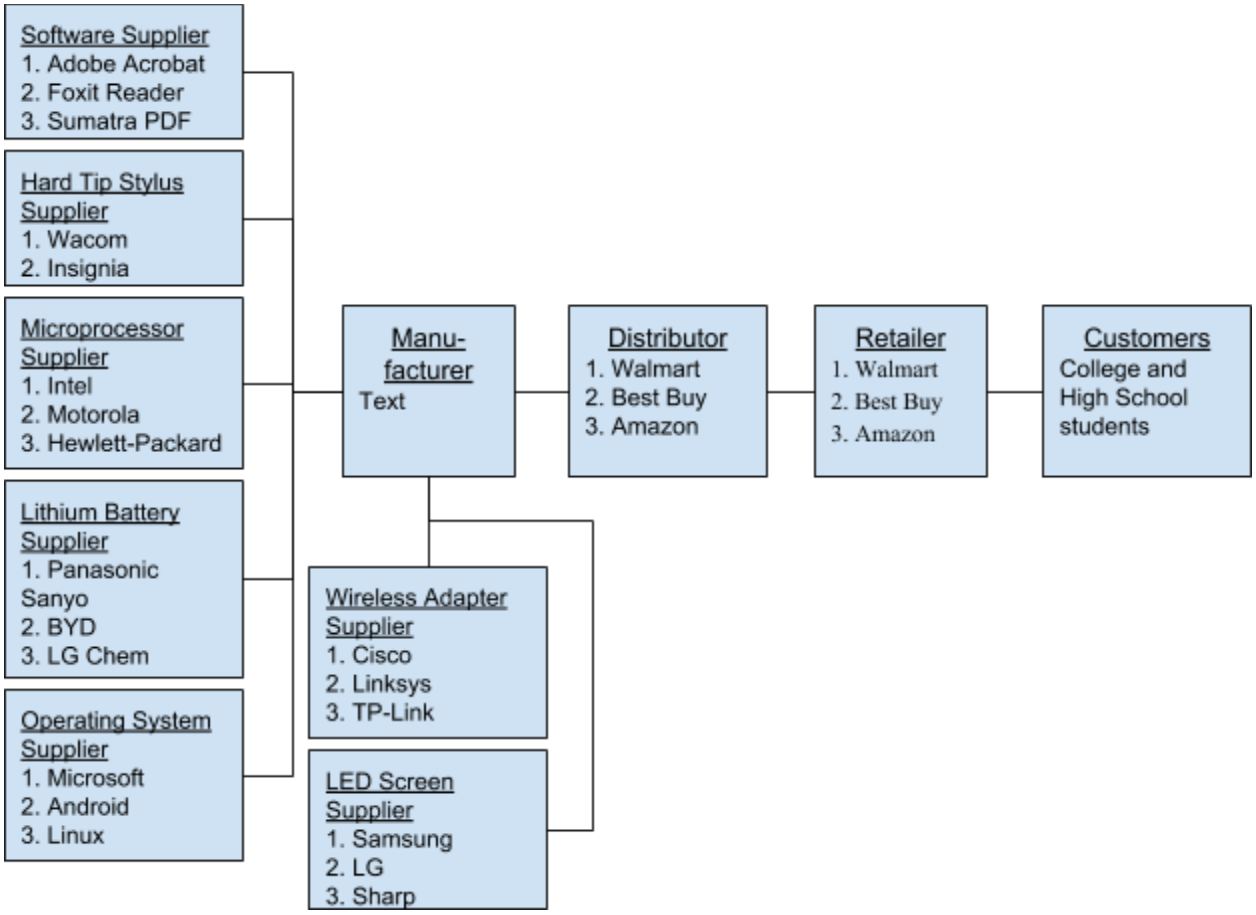
Section 7.0 Benchmarking with Plantronics

7.1 Benchmark Plantronics' supply chain network against our supply chain.

a. Plantronics' supply chain network:
    i. PLT manufacturers 75% of their own products
    ii. PLT buys raw material to forecast
    iii. Assemble to min-max settings
    iv. Pack to order
    v. Fulfill orders through distribution centers
    vi. Decentralized purchasing and planning

Plantronics aims to increase their supply chain efficiency by automating information. This means being demand driven, globally focused, have a virtual supply chain, decision based and lean practices. Ultimately they want to create quick responsiveness and real-time collaboration built by better Information flow to increase forecast accuracy.

7.2 Text's supply chain network



7.3 Comparison

In Text.book's supply chain network:

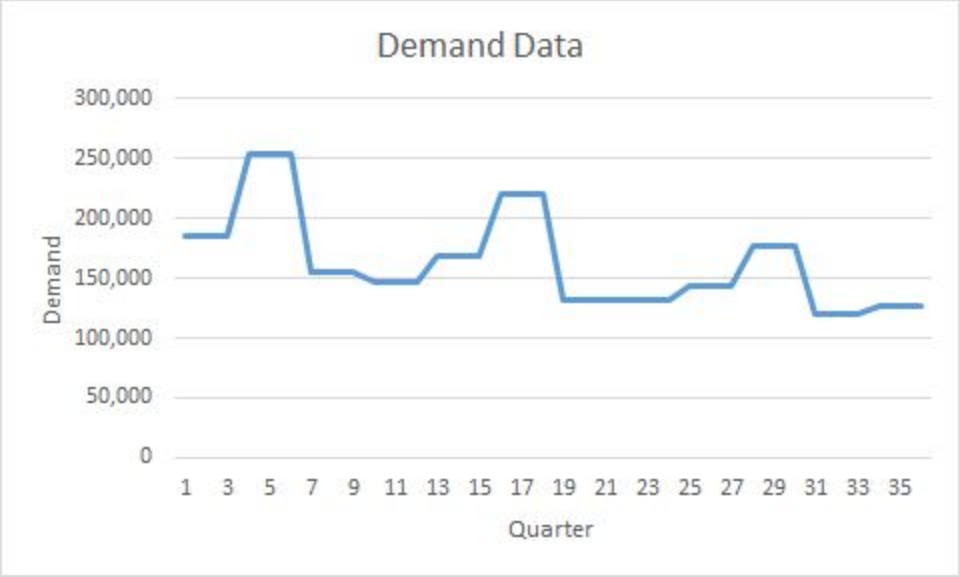
We can see that starting from the right are the customers and targeted market are primarily students. Customers can buy our product from a retailer such as Walmart, Best Buy, and Amazon. The manufacturer would be our company Text. We then pull the supplies for our product from several suppliers based on our listed subsystems above.

In PLT's supply chain network:

We can see that PLT is working on a big scale because they target companies not individuals. Even through they do provide audio devices for individuals, the majority of their money comes companies that buy large amounts of their devices. By manufacturing their own product they are able to produce when orders are placed.

Section 8.0 Demand Forecasting

1. Demand Data



Explanation: From the graph above we are given the data of the demand for a product such as ours. We can then use this data to determine any amount of seasonality, and that their is a periodicity of 4 with a total of 8 cycles.

2. Deseasonalized Demand and Regression

Since there are 4 periods in each cycle (even number), we have to use the following equation:

$$\overline{D_t'} = \frac{D_{t-\frac{p}{2}} + D_{t+\frac{p}{2}} + \sum_{i=t+1-\frac{p}{2}}^{t-1+\frac{p}{2}} 2D_i}{2p}$$

To determine the first deseasonalized value, start by averaging the first 12 demand values:

$$\frac{D_1 + D_2 + D_3 + D_4 + D_5 + D_6 + D_7 + D_8 + D_9 + D_{10} + D_{11} + D_{12}}{12} = \overline{D_{6.5}'}$$

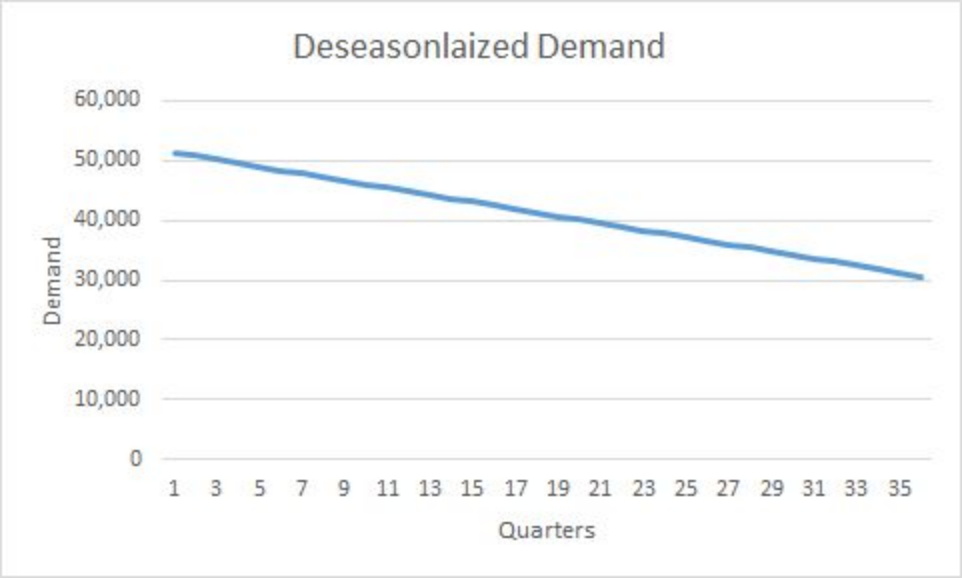
Next, average the first 12 demand values after the first one:

$$\frac{D_2 + D_3 + D_4 + D_5 + D_6 + D_7 + D_8 + D_9 + D_{10} + D_{11} + D_{12} + D_{13}}{12} = \overline{D_{7.5}'}$$

We take the average of the two above equations as follows:

$$\frac{D_1 + 2(D_2 + D_3 + D_4 + D_5 + D_6 + D_7 + D_8 + D_9 + D_{10} + D_{11} + D_{12}) + D_{13}}{2(12)} = \overline{D_7'}$$

Finally, after averaging the two equations above, we are left with $\overline{D_7'}$, our first deseasonalized value. A table of the deseasonalized demand values (see static forecast spreadsheet) are shown using a cell formula like the one below (used for the first deseasonalized value and copied over in Excel)



Explanation: The graph above shows the demand which has been stripped of the seasonality factor, we can now regress the data and get more relevant results.

The linear relationship between the deseasonalized demand and time is based on the change in demand over time.

$$\overline{D_t} = L + tT$$

$$\overline{D_t} = \ 19{,}126 + \text{t}19.058$$

With the above equation, it is now possible to determine the regressed deseasonalized demand for every quarter. After calculating each value, I placed the regressed deseasonalized demand values in a column next to the deseasonalized demand:

3. Estimate the seasonal factor for each time period

$$\overline{S_t} = \frac{D_t}{\overline{D_t}}$$

We carried out the calculations for each month and resulted with seasonal factors for each month (see static forecast spreadsheet)

Next, the seasonal factor for each corresponding period among all three cycles can be obtained by averaging the seasonal factors that correspond to similar periods, as shown in the next step.

4. Calculating Seasonality

Given a periodicity, p, obtaining the seasonal factor for a given period is possible by averaging the seasonal factors across each period that correspond similarly to periods in different cycles. For example, S_1, $S_{13,}$ and S_{25} are seasonal factors which correspond with one another. The formula, given *r* seasonal cycles and for all periods of the form *pt* + *i*, the average seasonal factor is obtainable through the following equation:

$$S_i = \frac{\sum_{j=0}^{r-1} \overline{S_{jp+1}}}{r}$$

Substituting the following values for i gives the seasonal factors that correspond with each other:

S_1: S_1, S_{13}, S_{25}

S_2: S_2, S_{14}, S_{26}

S_3: S_3, S_{15}, S_{27}

S_4: S_4, S_{16}, S_{28}

….

S_{12}: S_{12}, S_{24}, S_{36}

Now we take the calculated seasonal factors and input them into the following equations to compute the average seasonal factors for each given period (first one is done below as an example):

Average Seasonal Factors			
P1: 3.61	P4: 5.14	P7: 3.23	P10: 3.80
P2: 3.66	P5: 5.20	P8: 3.28	P11: 3.85
P3: 3.70	P6: 5.26	P9: 3.28	P12: 3.91

5. Use different methods to calculate the following information

   The first measure of error is the forecast error, which can be defined as the difference between the forecasted demand and the actual demand:

$$E_t = F_t - D_t$$

   Using the previously calculated forecast demand data, we used Excel to calculate the forecast error for all three cycles (see static forecast spreadsheet)

   - Mean square error (MSE)

   The mean squared error is another measure of forecast error which is found by:

$$MSE_n = \frac{1}{n} \sum_{t=1}^{n} E_t^2$$

- Absolute error

The absolute error or deviation is the absolute value of the forecast error:

$$A_t = |E_t|$$

- Mean absolute deviation (MAD)

The mean absolute deviation is the average of the absolute deviation over all periods:

$$MAD_n = \frac{1}{n} \sum_{t=1}^{n} A_t$$

- Percent error

The percent error is simply the percent difference between the forecast error demand and the actual demand data:

$$\% \text{ error} = \frac{|E_t|}{D_t}$$

The relevant data is below:

- Mean absolute percent error (MAPE)

The Mean absolute percent error is a measure of the average absolute error as a percentage of demand and is given by:

$$MAPE_n = \frac{\sum_{t=1}^{n} |\frac{E_t}{D_t}| 100}{n}$$

- Bias

The bias can help determine whether a forecast is consistently over- or underestimating demand:

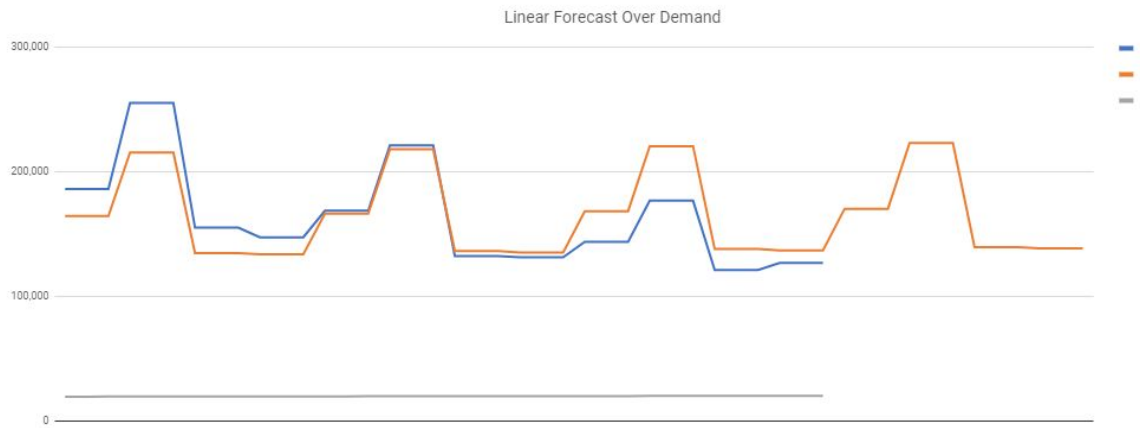
$$Bias_n = \sum_{t=1}^{n} E_t$$

- Tracking Signal (TS)

The tracking signal is an important metric of error analysis that consists of the ratio of the bias and the MAD:

$$TS_t = \frac{bias_t}{MAD_t}$$

6. Static Demand



The graph above shows us the static demand vs the forecasted demand, We can see how close the actual demand (blue line) is to the forecasted demand (orange line). We can see that our forecasted data also shows a similar trend to that of our actual data, and this is a good indicator for accuracy of our linear forecast of our demand.

7. Moving Average

Explanation: The graph above shows us the actual data vs the moving average forecasted data. The graph allows us to see that we were able to sell a lot more of our tabet than we had actually forecasted. Orange line (Forecasted demand) and the blue line (actual demand). In our moving average estimate we are able to get a better estimate of our demand since we are able to add more variables that will be added to our forecast, making a better prediction.

The following excel screenshot shows the calculations, and other information that was used to create a forecast for the next year.

Period t	Demand D_t	Level L_t	Forecast F_t	Error E_t	e Error A_t	Mean Squared Error MSE_t	MAD_t	% Error	$MAPE_t$	TS_t
1	185,667									
2	185,667									
3	185,667									
4	254,667	202,917								
5	254,667	220,167	202,917	-51,750	51,750	2,678,062,500	51,750	20	20	-1.00
6	254,667	237,417	220,167	-34,500	34,500	1,934,156,250	43,125	14	17	-2.00
7	154,667	229,667	237,417	82,750	82,750	3,571,958,333	56,333	54	29	-0.06
8	154,667	204,667	229,667	75,000	75,000	4,085,218,750	61,000	48	34	1.17
9	154,667	179,667	204,667	50,000	50,000	3,768,175,000	58,800	32	34	2.07
10	147,000	152,750	179,667	32,667	32,667	3,317,997,685	54,444	22	32	2.83
11	147,000	150,833	152,750	5,750	5,750	2,848,721,230	47,488	4	28	3.37
12	147,000	148,917	150,833	3,833	3,833	2,494,467,882	42,031	3	25	3.90
13	168,333	152,333	148,917	-19,417	19,417	2,259,194,444	39,519	12	23	3.65
14	168,333	157,667	152,333	-16,000	16,000	2,058,875,000	37,167	10	22	3.45
15	168,333	163,000	157,667	-10,667	10,667	1,882,047,980	34,758	6	20	3.39
16	220,667	181,417	163,000	-57,667	57,667	2,002,331,019	36,667	26	21	1.64
17	220,667	194,500	181,417	-39,250	39,250	1,966,810,363	36,865	18	21	0.56
18	220,667	207,583	194,500	-26,167	26,167	1,875,230,655	36,101	12	20	-0.15
19	132,000	198,500	207,583	75,583	75,583	2,131,071,296	38,733	57	22	1.81
20	132,000	176,333	198,500	66,500	66,500	2,274,269,965	40,469	50	24	3.38
21	132,000	154,167	176,333	44,333	44,333	2,256,103,758	40,696	34	25	4.45
22	131,000	131,750	154,167	23,167	23,167	2,160,581,019	39,722	18	24	5.14
23	131,000	131,500	131,750	750	750	2,046,895,833	37,671	1	23	5.44
24	131,000	131,250	131,500	500	500	1,944,563,542	35,813	0	22	5.74
25	143,333	134,083	131,250	-12,083	12,083	1,858,917,989	34,683	8	21	5.57

26	143,333	137,167	134,083	-9,250	9,250	1,778,310,922	33,527	6	21	5.49
27	143,333	140,250	137,167	-6,167	6,167	1,702,646,437	32,337	4	20	5.50
28	176,333	151,583	140,250	-36,083	36,083	1,685,953,125	32,493	20	20	4.37
29	176,333	159,833	151,583	-24,750	24,750	1,643,017,500	32,183	14	20	3.64
30	176,333	168,083	159,833	-16,500	16,500	1,590,295,673	31,580	9	19	3.19
31	120,667	162,417	168,083	47,417	47,417	1,614,667,695	32,167	39	20	4.60
32	120,667	148,500	162,417	41,750	41,750	1,619,253,224	32,509	35	21	5.84
33	120,667	134,583	148,500	27,833	27,833	1,590,130,508	32,348	23	21	6.73
34	126,333	122,083	134,583	8,250	8,250	1,539,394,907	31,544	7	20	7.16
35	126,333	123,500	122,083	-4,250	4,250	1,490,319,668	30,664	3	20	7.23
36	126,333	124,917	123,500	-2,833	2,833	1,443,998,047	29,794	2	19	7.34
37			124,917							
38			124,917							
39			124,917							
40			124,917							
41			124,917							
42			124,917							
43			124,917							
44			124,917							
45			124,917							
46			124,917							
47			124,917							
48			124,917							

8. Simple Exponential Smoothing Method

Explanation: The simple smoothing graph above shows how when we include seasonality we can get a more accurate forecast of the demand data, which will not have too much error in comparison to our actual sales. In our simple exponential smoothing graph, we get a non-fluctuating estimation based on the addition of the seasonality.

Period t	Demand D_t	Level L_t	Forecast F_t	Error E_t	e Error A_t	Mean Squared Error MSE_t	MAD_t	% Error	$MAPE_t$	TS_t
0		163,389								
1	185,667	164,726	163,389	-22,278	22,278	496,299,383	22,278	12	12	-1.00
2	185,667	165,982	164,726	-20,941	20,941	467,414,759	21,609	11	12	-2.00
3	185,667	167,163	165,982	-19,685	19,685	440,771,581	20,968	11	11	-3.00
4	254,667	172,413	167,163	-87,504	87,504	2,244,797,192	37,602	34	17	-4.00
5	254,667	177,349	172,413	-82,253	82,253	3,148,960,531	46,532	32	20	-5.00
6	254,667	181,988	177,349	-77,318	77,318	3,620,483,181	51,663	30	22	-6.00
7	154,667	180,348	181,988	27,321	27,321	3,209,904,680	48,186	18	21	-5.87
8	154,667	178,807	180,348	25,682	25,682	2,891,110,194	45,373	17	21	-5.66
9	154,667	177,359	178,807	24,141	24,141	2,634,628,762	43,014	16	20	-5.41
10	147,000	175,537	177,359	30,359	30,359	2,463,332,780	41,748	21	20	-4.85
11	147,000	173,825	175,537	28,537	28,537	2,313,428,588	40,547	19	20	-4.29
12	147,000	172,216	173,825	26,825	26,825	2,180,608,878	39,404	18	20	-3.73
13	168,333	171,983	172,216	3,882	3,882	2,014,029,177	36,671	2	19	-3.91
14	168,333	171,764	171,983	3,649	3,649	1,871,121,258	34,313	2	17	-4.07
15	168,333	171,558	171,764	3,430	3,430	1,747,164,377	32,254	2	16	-4.22
16	220,667	174,504	171,558	-49,109	49,109	1,788,695,638	33,307	22	17	-5.56
17	220,667	177,274	174,504	-46,162	46,162	1,808,828,059	34,063	21	17	-6.79
18	220,667	179,878	177,274	-43,392	43,392	1,812,943,422	34,582	20	17	-7.95
19	132,000	177,005	179,878	47,878	47,878	1,838,171,683	35,281	36	18	-6.43
20	132,000	174,305	177,005	45,005	45,005	1,847,536,047	35,768	34	19	-5.09
21	132,000	171,767	174,305	42,305	42,305	1,844,781,736	36,079	32	20	-3.87
22	131,000	169,321	171,767	40,767	40,767	1,836,469,293	36,292	31	20	-2.72
23	131,000	167,021	169,321	38,321	38,321	1,820,468,971	36,380	29	20	-1.66
24	131,000	164,860	167,021	36,021	36,021	1,798,679,969	36,365	27	21	-0.67

25	143,333	163,568	164,860	21,527	21,527	1,745,268,678	35,772	15	21	-0.08
26	143,333	162,354	163,568	20,235	20,235	1,693,891,352	35,174	14	20	0.49
27	143,333	161,213	162,354	19,021	19,021	1,644,554,534	34,576	13	20	1.05
28	176,333	162,120	161,213	-15,120	15,120	1,593,985,556	33,881	9	20	0.62
29	176,333	162,973	162,120	-14,213	14,213	1,545,986,447	33,203	8	19	0.21
30	176,333	163,775	162,973	-13,360	13,360	1,500,403,475	32,541	8	19	-0.20
31	120,667	161,188	163,775	43,108	43,108	1,511,948,503	32,882	36	19	1.12
32	120,667	158,757	161,188	40,522	40,522	1,516,012,404	33,121	34	20	2.33
33	120,667	156,471	158,757	38,090	38,090	1,514,038,249	33,272	32	20	3.47
34	126,333	154,663	156,471	30,138	30,138	1,496,222,648	33,179	24	20	4.38
35	126,333	152,963	154,663	28,330	28,330	1,476,404,309	33,041	22	20	5.26
36	126,333	151,366	152,963	26,630	26,630	1,455,091,978	32,863	21	20	6.10
37			151,366							
38			151,366							
39			151,366							
40			151,366							
41			151,366							
42			151,366							
43			151,366							
44			151,366							
45			151,366							
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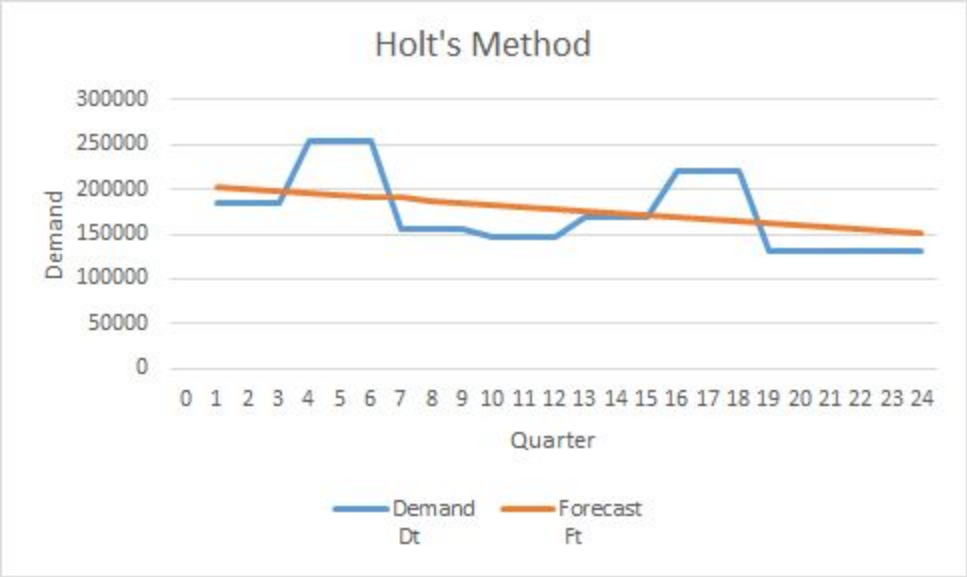
47			151,366							
48			151,366							

9. Holt's Method



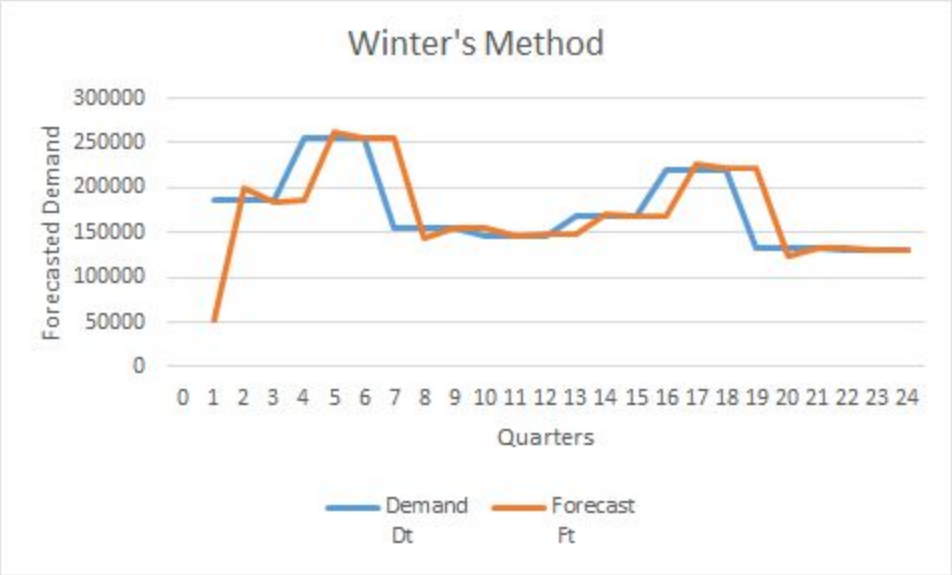
Explanation: In Holt's method we use both level and trend to determine a forecast against our actual demand to determine an accuracy and we are able to determine that our data is very close to a linear pattern. Below we show the tables that we used to calculate our forecast and its accuracy.

Period t	Demand D_t	Level L_t	Trend T_t	Forecast F_t	Error E_t	e Error A_t	Mean Squared Error MSE_t	MAD_t	% Error	$MAPE_t$	TS_t
0		204,660	-2,231								
1	185,667	202,262	-2,233	202,429	16,763	16,763	280,990,215	16,763	9	9	1.00
2	185,667	199,886	-2,234	200,029	14,363	14,363	243,636,828	15,563	8	8	2.00
3	185,667	197,532	-2,235	197,652	11,985	11,985	210,304,184	14,370	6	8	3.00
4	254,667	195,890	-2,229	195,297	-59,370	59,370	1,038,930,449	25,620	23	12	-0.63
5	254,667	194,271	-2,223	193,661	-61,006	61,006	1,575,482,590	32,697	24	14	-2.36
6	254,667	192,674	-2,217	192,048	-62,619	62,619	1,966,420,547	37,684	25	16	-3.71
7	154,667	190,099	-2,220	190,457	35,791	35,791	1,868,497,783	37,414	23	17	-2.78
8	154,667	187,547	-2,224	187,879	33,212	33,212	1,772,816,295	36,888	21	17	-1.92
9	154,667	185,016	-2,227	185,323	30,656	30,656	1,680,259,308	36,196	20	18	-1.11
10	147,000	182,432	-2,230	182,789	35,789	35,789	1,640,321,866	36,155	24	18	-0.12
11	147,000	179,869	-2,234	180,201	33,201	33,201	1,591,412,054	35,887	23	19	0.80
12	147,000	177,329	-2,237	177,635	30,635	30,635	1,537,004,709	35,449	21	19	1.68
13	168,333	175,025	-2,238	175,092	6,759	6,759	1,422,287,553	33,242	4	18	1.99
14	168,333	172,743	-2,238	172,787	4,454	4,454	1,322,112,422	31,186	3	17	2.26
15	168,333	170,483	-2,238	170,505	2,171	2,171	1,234,285,880	29,252	1	16	2.49
16	220,667	168,769	-2,233	168,245	-52,422	52,422	1,328,896,935	30,700	24	16	0.66
17	220,667	167,077	-2,228	166,536	-54,131	54,131	1,423,087,100	32,078	25	17	-1.05
18	220,667	165,408	-2,222	164,850	-55,817	55,817	1,517,111,360	33,397	25	17	-2.68
19	132,000	162,874	-2,225	163,186	31,186	31,186	1,488,451,204	33,280	24	17	-1.75
20	132,000	160,363	-2,228	160,649	28,649	28,649	1,455,067,248	33,049	22	18	-0.90
21	132,000	157,873	-2,231	158,135	26,135	26,135	1,418,303,254	32,720	20	18	-0.11
22	131,000	155,396	-2,233	155,643	24,643	24,643	1,381,438,092	32,353	19	18	0.65
23	131,000	152,942	-2,235	153,163	22,163	22,163	1,342,732,841	31,910	17	18	1.35
24	131,000	150,510	-2,237	150,707	19,707	19,707	1,302,966,863	31,401	15	18	2.00
25	143,333	148,223	-2,238	148,272	4,939	4,939	1,251,823,939	30,343	3	17	2.24
26	143,333	145,959	-2,238	145,985	2,652	2,652	1,203,947,357	29,278	2	17	2.41
27	143,333	143,717	-2,238	143,721	387	387	1,159,362,275	28,208	0	16	2.51
28	176,333	141,828	-2,234	141,479	-34,854	34,854	1,161,343,146	28,445	20	16	1.27
29	176,333	139,960	-2,231	139,593	-36,740	36,740	1,167,843,396	28,731	21	16	-0.03
30	176,333	138,116	-2,227	137,730	-38,604	38,604	1,178,590,198	29,060	22	16	-1.35
31	120,667	135,736	-2,228	135,889	15,222	15,222	1,148,045,677	28,614	13	16	-0.84
32	120,667	133,380	-2,230	133,508	12,841	12,841	1,117,322,364	28,121	11	16	-0.40
33	120,667	131,045	-2,231	131,150	10,483	10,483	1,086,794,306	27,586	9	16	-0.03
34	126,333	128,789	-2,231	128,814	2,481	2,481	1,055,010,785	26,848	2	15	0.06
35	126,333	126,556	-2,231	126,558	225	225	1,024,869,066	26,087	0	15	0.07
36	126,333	124,345	-2,231	124,325	-2,008	2,008	996,512,522	25,418	2	15	0.00
37				122,114							
38				119,883							
39				117,652							
40				115,422							
41				113,191							
42				110,960							
43				108,729							
44				106,498							
45				104,267							
46				102,036							
47				99,805							
48				97,574							

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.59377562							
R Square	0.352569487							
Adjusted R Square	0.333527414							
Standard Error	32315.28913							
Observations	36							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	19335106564	19335106564	18.51528827	0.000134805			
Residual	34	35505448992	1044277912					
Total	35	54840555556						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	204660.3175	11000.16505	18.60520425	2.1282E-19	182305.2924	227015.3425	182305.2924	227015.3425
X Variable 1	-2230.888031	518.4567515	-4.302939492	0.000134805	-3284.518918	-1177.257144	-3284.518918	-1177.257144

Explanation: Above is the screenshot of the results of our regression when we use the trend and level in-order to create a forecast using Holt's method.

10. Winter's Method



Explanation: Above is a screenshot of the accuracy of our demand data when we include three factors seasonality, trend, and level.

Demand D_t	Level L_t	Trend T_t	Seasonal Factor S_t	Forecast F_t	Error E_t	Absolute Error A_t	Mean Squared Error MSE_t	MAD_t	% Error	$MAPE_t$	Bias	TS_t
	51,953	-591										
185,667	199,097	886	4.04	51,362	-134,304	134,304	18,037,672,673	134,304	72	72	-134,304	-1.00
185,667	184,235	729	4.04	199,983	14,317	14,317	9,121,318,703	74,310	8	40	-119,988	-1.61
185,667	185,737	736	3.39	184,964	-703	703	6,081,043,868	49,775	0	27	-120,691	-2.42
254,667	261,486	1,487	3.90	186,473	-68,193	68,193	5,723,364,483	54,379	27	27	-188,884	-3.47
254,667	253,836	1,395	2.49	262,973	8,306	8,306	4,592,489,035	45,165	3	22	-180,578	-4.00
254,667	254,610	1,389	2.52	255,231	565	565	3,827,127,320	37,731	0	18	-180,014	-4.77
154,667	144,533	274	2.19	255,999	101,332	101,332	4,747,291,167	46,817	66	25	-78,681	-1.68
154,667	155,653	383	2.43	144,808	-9,859	9,859	4,166,029,647	42,197	6	23	-88,540	-2.10
154,667	154,530	368	2.49	156,035	1,369	1,369	3,703,345,594	37,661	1	20	-87,171	-2.31
147,000	146,210	281	2.52	154,897	7,897	7,897	3,339,248,070	34,685	5	19	-79,274	-2.29
147,000	147,051	286	2.19	146,491	-509	509	3,035,703,610	31,578	0	17	-79,783	-2.53
147,000	146,966	283	2.43	147,337	337	337	2,782,737,791	28,974	0	16	-79,446	-2.74
168,333	170,442	515	2.49	147,249	-21,084	21,084	2,602,877,214	28,367	13	16	-100,530	-3.54
168,333	168,071	486	2.52	170,956	2,623	2,623	2,417,448,875	26,528	2	15	-97,907	-3.69
168,333	168,311	483	2.19	168,557	223	223	2,256,288,946	24,775	0	14	-97,683	-3.94
220,667	225,854	1,054	2.43	168,794	-51,872	51,872	2,283,442,256	26,468	24	14	-149,556	-5.65
220,667	220,043	985	2.49	226,908	6,241	6,241	2,151,413,415	25,279	3	14	-143,315	-5.67
220,667	220,631	981	2.52	221,028	361	361	2,031,897,693	23,894	0	13	-142,954	-5.98
132,000	123,039	-4	2.19	221,612	89,612	89,612	2,347,602,137	27,353	68	16	-53,342	-1.95
132,000	132,897	94	2.43	123,034	-8,966	8,966	2,234,241,152	26,434	7	15	-62,307	-2.36
132,000	131,901	83	2.49	132,991	991	991	2,127,895,458	25,222	1	15	-61,317	-2.43
131,000	130,902	72	2.52	131,984	984	984	2,031,216,967	24,120	1	14	-60,332	-2.50
131,000	131,003	73	2.19	130,974	-26	26	1,942,903,215	23,073	0	13	-60,358	-2.62
131,000	130,992	72	2.43	131,075	75	75	1,861,949,151	22,115	0	13	-60,283	-2.73
143,333	144,560	207	2.49	131,064	-12,269	12,269	1,793,492,274	21,721	9	13	-72,552	-3.34
143,333	143,190	191	2.52	144,767	1,434	1,434	1,724,590,867	20,941	1	12	-71,118	-3.40
143,333	143,329	191	2.19	143,381	48	48	1,660,717,216	20,167	0	12	-71,070	-3.52
176,333	179,615	552	2.43	143,519	-32,814	32,814	1,639,862,012	20,618	19	12	-103,885	-5.04
176,333	175,950	509	2.49	180,166	3,833	3,833	1,583,821,650	20,040	2	12	-100,052	-4.99
176,333	176,321	508	2.52	176,459	126	126	1,531,028,125	19,376	0	11	-99,926	-5.16
120,667	115,050	-110	2.19	176,829	56,162	56,162	1,583,387,699	20,562	47	12	-43,764	-2.13
120,667	121,239	-47	2.43	114,941	-5,726	5,726	1,534,931,431	20,099	5	12	-49,490	-2.46
120,667	120,614	-53	2.49	121,192	526	526	1,488,426,735	19,506	0	12	-48,964	-2.51
126,333	126,911	11	2.52	120,561	-5,772	5,772	1,445,629,306	19,102	5	12	-54,736	-2.87
126,333	126,275	4	2.19	126,921	588	588	1,404,335,493	18,573	0	11	-54,148	-2.92
126,333	126,339	5	2.43	126,279	-54	54	1,365,326,256	18,058	0	11	-54,202	-3.00
			2.49	126,344								
			2.52	126,349								
			2.19	126,354								
			2.43	126,359								
			2.49	126,364								
			2.52	126,369								
			2.19	126,374								
			2.43	126,379								
			2.49	126,384								
			2.52	126,389								
			2.19	126,394								
			2.43	126,399								

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.711465857							
R Square	0.506183665							
Adjusted R Square	0.489723121							
Standard Error	5568.319204							
Observations	32							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	953481290.3	953481290.3	30.75133178	4.99668E-06			
Residual	30	930185362.8	31006178.76					
Total	31	1883666653						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	51953.46293	2204.296443	23.5691815	6.52075E-21	47451.68902	56455.23684	47451.68902	56455.23684
X Variable 1	-591.1992913	106.6109812	-5.545388335	4.99668E-06	-808.9279617	-373.4706209	-808.9279617	-373.4706209

Period t	Demand D_t	*sonalized Dema*	*sonalized Dema*	*sal Factor*	*Estimate*
1	185,667		51,362	3.61	4.04
2	185,667		50,771	3.66	4.04
3	185,667	52,885	50,180	3.70	3.33
4	254,667	57,198	49,589	5.14	3.30
5	254,667	58,385	48,997	5.20	
6	254,667	54,292	48,406	5.26	
7	154,667	48,042	47,815	3.23	
8	154,667	41,552	47,224	3.28	
9	154,667	37,948	46,633	3.32	
10	147,000	37,469	46,041	3.19	
11	147,000	37,656	45,450	3.23	
12	147,000	38,750	44,859	3.28	
13	168,333	40,083	44,268	3.80	
14	168,333	43,052	43,677	3.85	
15	168,333	46,990	43,085	3.91	
16	220,667	50,260	42,494	5.19	
17	220,667	50,760	41,903	5.27	
18	220,667	46,854	41,312	5.34	
19	132,000	41,313	40,721	3.24	
20	132,000	35,740	40,129	3.29	
21	132,000	32,906	39,538	3.34	
22	131,000	32,844	38,947	3.36	
23	131,000	33,167	38,356	3.42	
24	131,000	33,906	37,765	3.47	
25	143,333	34,677	37,173	3.86	
26	143,333	36,479	36,582	3.92	
27	143,333	38,927	35,991	3.98	
28	176,333	40,990	35,400	4.98	
29	176,333	41,313	34,809	5.07	
30	176,333	38,865	34,217	5.15	
31	120,667	35,385	33,626	3.59	
32	120,667	32,083	33,035	3.65	
33	120,667	30,698	32,444	3.72	
34	126,333	31,052	31,853	3.97	
35	126,333		31,261	4.04	
36	126,333		30,670	4.12	

Explanation: The graphs above show us winter's models calculations, the regression figure gives us the values that we should use based on our seasonality calculations shown above.

11. Accuracy

TEXTBOOK				
			TS Range	
Forecasting Method	MAD	MAPE(%)	Min	Max
Moving Average	29,794	19	-2.00	3.90
Simple exponential smoothing	32,863	20	-7.95	-2.00
Holt's model	25,418	15	-3.71	3.00
Winter's model	18,058	11	-5.98	-1.00
Forecast	**Winter's Method**			
Year	Quarter	Forecast		
2014	1	126,344		
	2	126,349		
	3	126,354		
	4	126,359		
Total		**505,405**		

Explanation: Using the table above we are able to determine that it would be in the best interests of Text.book to use winter's method of forecasting in-order to determine our demand forecast for the following year. This is because winter's method is the most accurate representation of the current demand that we have been facing and this will allow us to accurately determine the needed demand for the future.

Section 9.0 Inventory

Cycle Inventory

1. Read the instructor's email, textbook, and lecture notes on how to perform cycle inventory.

After reading through the instructor's email, textbook, and lecture notes, our group was able to set up an approach to cycle inventory by first explaining the specific parts of the supply chain as a transition to solving for our desired cycle inventory.

2. Explain why our company, Text.book, should have a cycle inventory.

The main reason why we, Text.book, should have a cycle inventory is to properly manage our inventory count each day. Cycle inventory keeps more accurate data with less chances of error since cycle inventory is updated on a frequent basis. With updated inventory levels, management will be able to assess inventory related problems quickly. In general, a cycle inventory provides an efficient way of managing inventory levels for our company.

3. Examine the stage and network models for our product's supply chain.

In order to plan the approach for cycle inventory, we first have to examine our supply chain network. Our group began by assessing our supply chain flow:

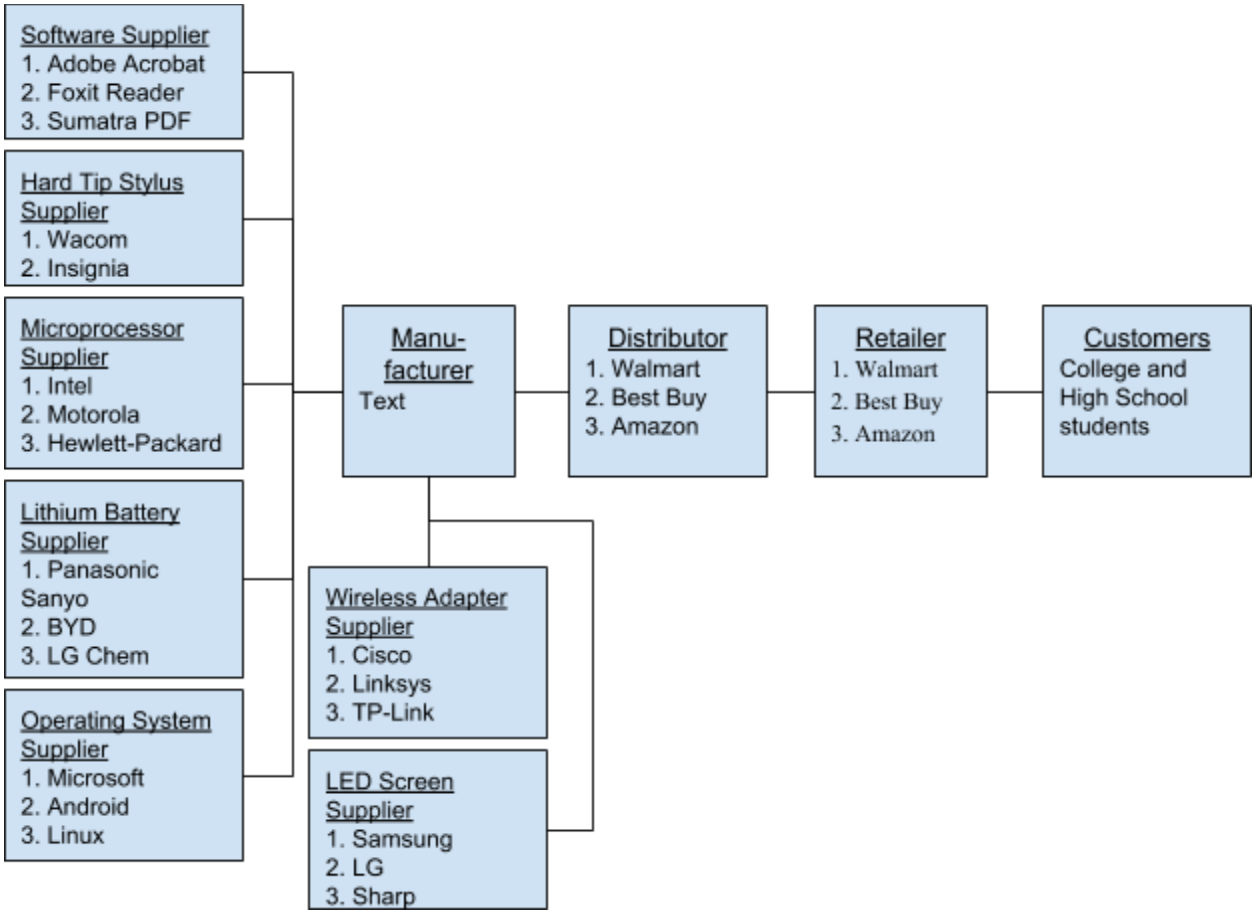


Figure 9.1: Supply chain flow

Although not explicitly shown in Figure 1, the black lines represent the flow of inventory from one facility to another. Each facility is dependent on having a certain amount of inventory on hand in order to ship to the next stage in the supply chain. In the beginning of the supply chain, the component suppliers must have a certain amount of demanded components in store so that they can proceed to ship to the manufacturer for assembly. Next, the manufacturer can optimally lower costs by having a certain amount of inventory that is regularly shipped and stored, requiring stable communication between the supplier and the distributor. The overall flow of the product inventory and information is better presented in the supply chain network below:

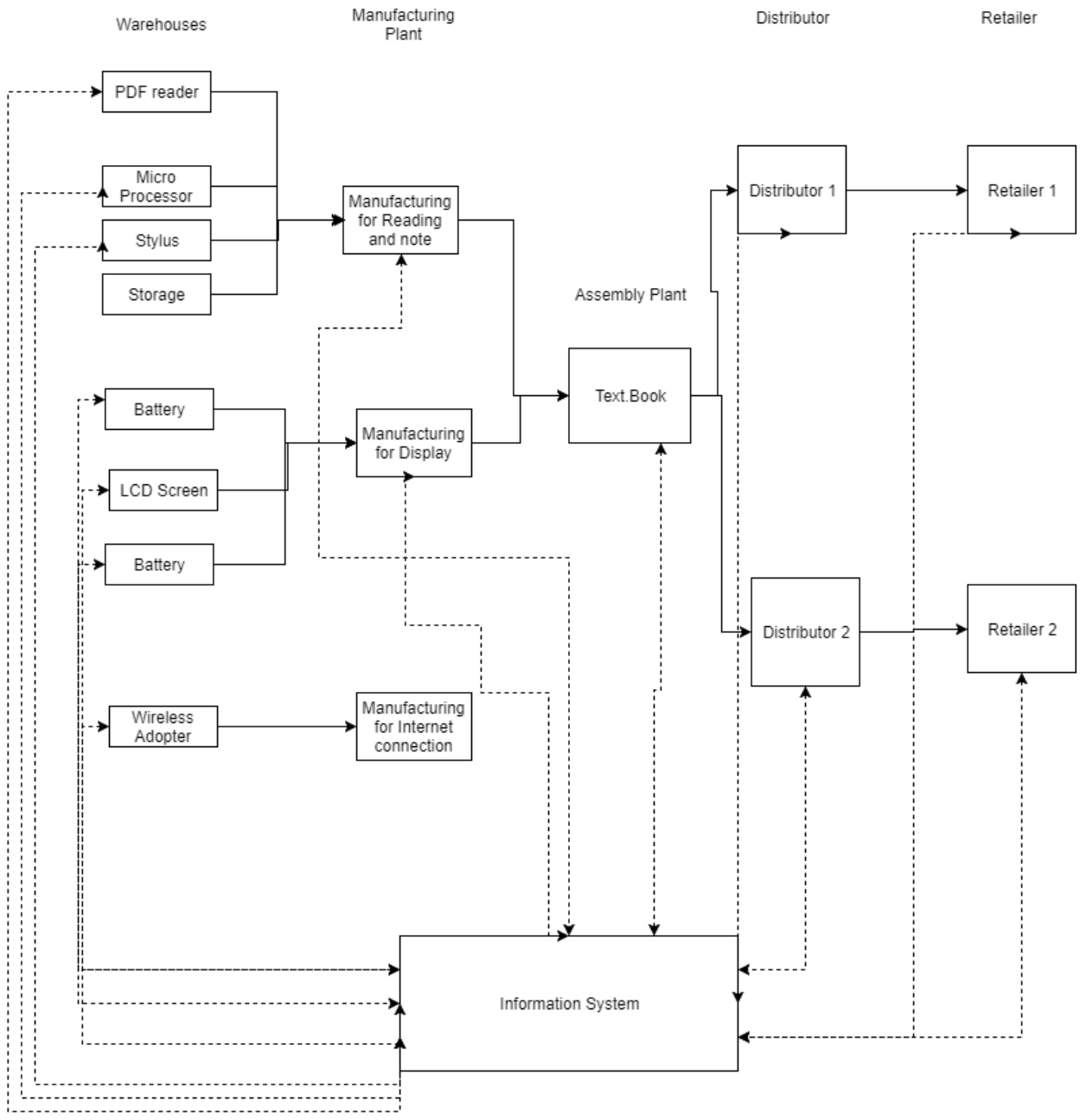


Figure 9.2: Supply chain network

The above diagram is similar to the supply chain flow in Figure 1, but with the addition of showing the distributing plants and how they are involved in the whole supply chain. As stated earlier, every facility depends on an efficient transfer of inventory from one to another. Although

inventory should be accounted for in every piece of the supply chain, we will be focused mainly on the inventory of our component suppliers and our distributing plants.

4. Answer the following supply chain-related questions
    a. Which stages of the SC do we need to be concerned with?

Since we are the manufacturers, our company Text is mostly concerned with the flow between the supplier stage, the manufacturing stage, and the distribution stage. In other words, the stages that involve manufacturing the product and delivering the product is what we as a company should focus on.

    b. What is the specific supply (components, subsystems, product) that are flowing between these stages?

Between our company and our suppliers, the necessary components that make up our product are flowing. We purchase each type of component separately from each unique component supplier. Another way of approaching cycle inventory is to aggregate the supplied components in order to reduce costs. In addition, the flow of products between our manufacturing plants and our distributors need to be assessed.

    c. What are the numerical values of the parameters of interest?

Cycle inventory is defined as the average inventory needed to meet customer demand between the order time and when the supply arrives. Costs are also a key part of the equation due to costs incurred from inventory storage. Therefore, we need to know the annual demand of our product as well as the material cost, shipping cost, and holding cost:

Demand (D) = Annual demand (obtained through forecasting)
Cost (C) = Price paid by the manufacturer to the supplier for 1 unit of supply

Percent inventory holding cost (h) = cost of holding $1 of inventory for 1 year.
Fixed ordering cost (S) = cost of placing the order and labor for receiving.

5. Using the numerical values from the previous step, solve for cycle inventory.

Before approaching the manual implementation of performing cycle inventory, we first need to define and provide the variables that are necessary for calculating the cycle inventory value.

Demand (D) = Annual demand (obtained through forecasting)
Cost (C) = $75
Lot size (Q) = Number of units in 1 lot of shipment (quantity per shipment)
Percent inventory holding cost (h) = 0.10
Fixed ordering cost (S) = $10,000

Explanation: The annual demand is obtained through forecasting by adding up the quarterly demand values in each year. The unit production cost was based off of researching the cost for John Deere tractor parts. Assuming that we can proportionally scale down component costs, we estimated our product to cost around $75 per unit.
Percent inventory holding cost was estimated as 10% after evaluating various related product information.
The shipment cost was based off of researching transportation services and the costs depending on the size of the delivery truck and the size of our product.

Given the ordering cost and the material cost for 1 unit, we were able to compute the total annual costs by multiplying the costs against our yearly demand. Once we had the individual costs totaled up, the summation of the individual costs results in the total annual cost.

Next, the optimal lot size can be computed with the above variables defined. The lot size that minimizes the total cost is given by the following formula:

$$Q_L^* = \sqrt{\frac{2DS}{hC}}$$

Once we obtained the optimal lot size value for each year, we can now calculate the cycle inventory. Through analyzing the theory behind average inventory, it turn out that the cycle inventory can be calculated by dividing the optimal lot size by 2.

Cycle inventory is defined as the average inventory held during each year. It plays an important role in a supply chain because different stages exploit economies of scale to lower total cost. Provided in the table below is a compilation of all the costs related to cycle inventory.

Month	Period	Demand	Annual Demand	Unit Cost ($)	Holding Cost (%)	Shipment Cost ($)	Optimal Lot Size	Number of Shipments	Cycle Inventory	Cycle Inventory holding cost ($)	Replenishment Cycle Time	Annual Ordering Cost	Material Cost	Annual Total Cost
January	1	185,667		75	10.00%	10,000.00	22,251.11	100	11,125.56	83,441.67	3.648537761	83,441.67	166,950,225.00	167,033,666.67
February	2	185,667		75	10.00%	10,000.00	22,251.11	100	11,125.56	83,441.67	3.648537761	83,441.67	166,950,225.00	167,033,666.67
March	3	185,667		75	10.00%	10,000.00	22,251.11	100	11,125.56	83,441.67	3.648537761	83,441.67	166,950,225.00	167,033,666.67
April	4	254,667		75	10.00%	10,000.00	26,059.78	85	13,029.89	97,724.17	4.273048493	97,724.17	166,950,225.00	167,047,949.17
May	5	254,667		75	10.00%	10,000.00	26,059.78	85	13,029.89	97,724.17	4.273048493	97,724.17	166,950,225.00	167,047,949.17
June	6	254,667		75	10.00%	10,000.00	26,059.78	85	13,029.89	97,724.17	4.273048493	97,724.17	166,950,225.00	167,047,949.17
July	7	154,667		75	10.00%	10,000.00	20,308.75	110	10,154.38	76,157.81	3.33004664	76,157.81	166,950,225.00	167,026,382.81
August	8	154,667		75	10.00%	10,000.00	20,308.75	110	10,154.38	76,157.81	3.33004664	76,157.81	166,950,225.00	167,026,382.81
September	9	154,667		75	10.00%	10,000.00	20,308.75	110	10,154.38	76,157.81	3.33004664	76,157.81	166,950,225.00	167,026,382.81
October	10	147,000		75	10.00%	10,000.00	19,798.99	112	9,899.49	74,246.21	3.246460721	74,246.21	166,950,225.00	167,024,471.21
November	11	147,000		75	10.00%	10,000.00	19,798.99	112	9,899.49	74,246.21	3.246460721	74,246.21	166,950,225.00	167,024,471.21
December	12	147,000	2,226,003	75	10.00%	10,000.00	19,798.99	112	9,899.49	74,246.21	3.246460721	74,246.21	166,950,225.00	167,024,471.21
January	13	168,333		75	10.00%	10,000.00	21,186.98	92	10,593.49	79,451.16	3.953602583	79,451.16	146,700,000.00	146,779,451.16
February	14	168,333		75	10.00%	10,000.00	21,186.98	92	10,593.49	79,451.16	3.953602583	79,451.16	146,700,000.00	146,779,451.16
March	15	168,333		75	10.00%	10,000.00	21,186.98	92	10,593.49	79,451.16	3.953602583	79,451.16	146,700,000.00	146,779,451.16
April	16	220,667		75	10.00%	10,000.00	24,257.89	81	12,128.95	90,967.10	4.526651661	90,967.10	146,700,000.00	146,790,967.10
May	17	220,667		75	10.00%	10,000.00	24,257.89	81	12,128.95	90,967.10	4.526651661	90,967.10	146,700,000.00	146,790,967.10
June	18	220,667		75	10.00%	10,000.00	24,257.89	81	12,128.95	90,967.10	4.526651661	90,967.10	146,700,000.00	146,790,967.10
July	19	132,000		75	10.00%	10,000.00	18,761.66	104	9,380.83	70,356.24	3.501026078	70,356.24	146,700,000.00	146,770,356.24
August	20	132,000		75	10.00%	10,000.00	18,761.66	104	9,380.83	70,356.24	3.501026078	70,356.24	146,700,000.00	146,770,356.24
September	21	132,000		75	10.00%	10,000.00	18,761.66	104	9,380.83	70,356.24	3.501026078	70,356.24	146,700,000.00	146,770,356.24
October	22	131,000		75	10.00%	10,000.00	18,690.46	105	9,345.23	70,089.23	3.487739404	70,089.23	146,700,000.00	146,770,089.23
November	23	131,000		75	10.00%	10,000.00	18,690.46	105	9,345.23	70,089.23	3.487739404	70,089.23	146,700,000.00	146,770,089.23
December	24	131,000	1,956,000	75	10.00%	10,000.00	18,690.46	105	9,345.23	70,089.23	3.487739404	70,089.23	146,700,000.00	146,770,089.23
January	25	143,333		75	10.00%	10,000.00	19,550.48	87	9,775.24	73,314.31	4.197608355	73,314.31	127,499,850.00	127,573,164.31
February	26	143,333		75	10.00%	10,000.00	19,550.48	87	9,775.24	73,314.31	4.197608355	73,314.31	127,499,850.00	127,573,164.31
March	27	143,333		75	10.00%	10,000.00	19,550.48	87	9,775.24	73,314.31	4.197608355	73,314.31	127,499,850.00	127,573,164.31
April	28	176,333		75	10.00%	10,000.00	21,684.59	78	10,842.29	81,317.20	4.655813962	81,317.20	127,499,850.00	127,581,167.20
May	29	176,333		75	10.00%	10,000.00	21,684.59	78	10,842.29	81,317.20	4.655813962	81,317.20	127,499,850.00	127,581,167.20
June	30	176,333		75	10.00%	10,000.00	21,684.59	78	10,842.29	81,317.20	4.655813962	81,317.20	127,499,850.00	127,581,167.20
July	31	120,667		75	10.00%	10,000.00	17,938.19	95	8,969.10	67,268.21	3.85143948	67,268.21	127,499,850.00	127,567,118.21
August	32	120,667		75	10.00%	10,000.00	17,938.19	95	8,969.10	67,268.21	3.85143948	67,268.21	127,499,850.00	127,567,118.21
September	33	120,667		75	10.00%	10,000.00	17,938.19	95	8,969.10	67,268.21	3.85143948	67,268.21	127,499,850.00	127,567,118.21
October	34	126,333		75	10.00%	10,000.00	18,354.51	93	9,177.25	68,829.41	3.940825683	68,829.41	127,499,850.00	127,568,679.41
November	35	126,333		75	10.00%	10,000.00	18,354.51	93	9,177.25	68,829.41	3.940825683	68,829.41	127,499,850.00	127,568,679.41
December	36	126,333	1,699,998	75	10.00%	10,000.00	18,354.51	93	9,177.25	68,829.41	3.940825683	68,829.41	127,499,850.00	127,568,679.41
January	37	124,917		75	10.00%	10,000.00	18,251.36	82	9,125.68	68,442.59	4.444114213	68,442.59	112,425,300.00	112,493,742.59
February	38	124,917		75	10.00%	10,000.00	18,251.36	82	9,125.68	68,442.59	4.444114213	68,442.59	112,425,300.00	112,493,742.59
March	39	124,917		75	10.00%	10,000.00	18,251.36	82	9,125.68	68,442.59	4.444114213	68,442.59	112,425,300.00	112,493,742.59
April	40	124,917		75	10.00%	10,000.00	18,251.36	82	9,125.68	68,442.59	4.444114213	68,442.59	112,425,300.00	112,493,742.59
May	41	124,917		75	10.00%	10,000.00	18,251.36	82	9,125.68	68,442.59	4.444114213	68,442.59	112,425,300.00	112,493,742.59
June	42	124,917		75	10.00%	10,000.00	18,251.36	82	9,125.68	68,442.59	4.444114213	68,442.59	112,425,300.00	112,493,742.59
July	43	124,917		75	10.00%	10,000.00	18,251.36	82	9,125.68	68,442.59	4.444114213	68,442.59	112,425,300.00	112,493,742.59
August	44	124,917		75	10.00%	10,000.00	18,251.36	82	9,125.68	68,442.59	4.444114213	68,442.59	112,425,300.00	112,493,742.59
September	45	124,917		75	10.00%	10,000.00	18,251.36	82	9,125.68	68,442.59	4.444114213	68,442.59	112,425,300.00	112,493,742.59
October	46	124,917		75	10.00%	10,000.00	18,251.36	82	9,125.68	68,442.59	4.444114213	68,442.59	112,425,300.00	112,493,742.59
November	47	124,917		75	10.00%	10,000.00	18,251.36	82	9,125.68	68,442.59	4.444114213	68,442.59	112,425,300.00	112,493,742.59
December	48	124,917	1499004	75	10.00%	10,000.00	18,251.36	82	9,125.68	68,442.59	4.444114213	68,442.59	112,425,300.00	112,493,742.59

Figure 9.3: Cycle inventory

Explanation: The above results currently shows the optimal lot size for each year, as well as the cycle inventory and the total annual costs. Based on the above table, an average optimal lot size of around 20,000 units per order results in a cycle inventory of around 10,000 units per cycle. The average inventory of 80,000 units per cycle results in a total annual cost of roughly $167 million dollars per year.

6. Create a diagram showing our product inventory as a function of time to illustrate the above values.

With the initial assumption that we have no safety inventory, our ideal cycle inventory model looks like the following:

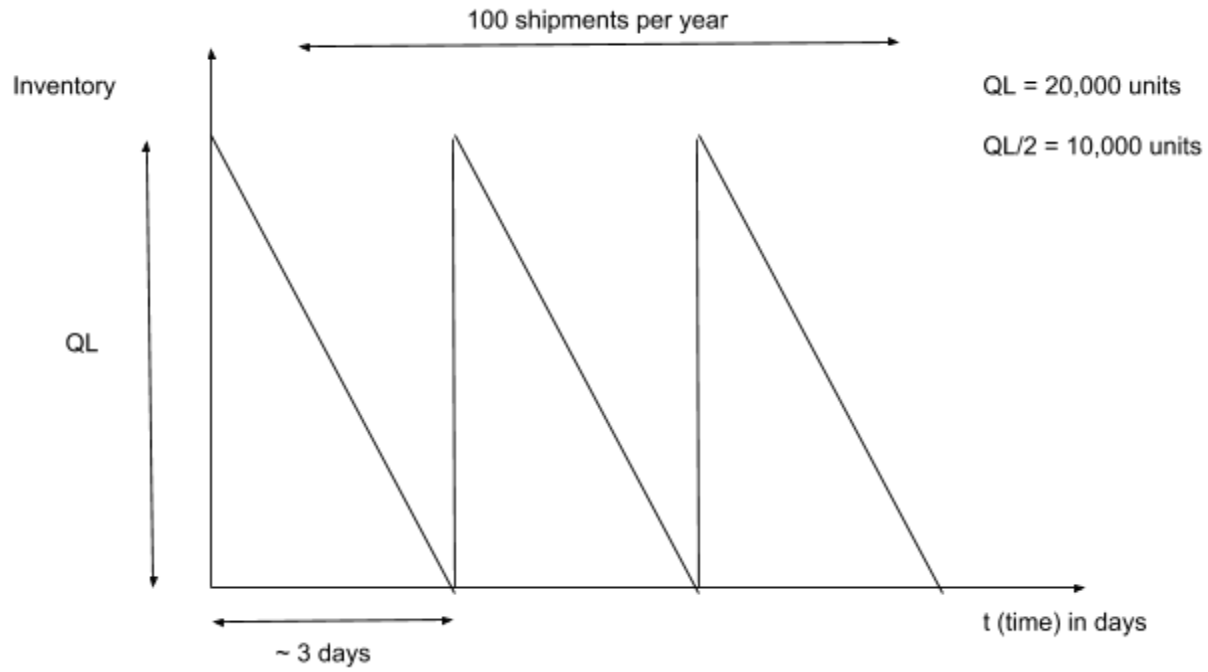


Figure 9.4: Cycle Inventory Management

The above diagram displays our cycle inventory over a span of one year. Based on the calculations presented in Figure 3, we were able to compute the average amount of shipments per year to be 100, with one shipment ideally every 3 days. Cycle inventory is shown as the value between the horizontal dotted line and the x-axis. From the graph above, we would ideally ship a total of 20,000 units every 3 days, thus having a cycle inventory of 10,000 units.

Conclusion**:** From our demand forecasting results, the annual demand for 2018 is estimated to be 9,303 units. We were able to determine that ideally we should have 100 shipments per year with a cycle inventory of 10,000 units during the year and costs totaling around $167 million dollars.

In particular for the year 2018, the cycle inventory is an estimated 9,125 units with costs totaling $112 million dollars. From these calculations, we can now solve for the optimal amount of safety inventory that our company should hold.

**Note: The software automation can be performed as shown in the user manual in later sections.

Safety Inventory

1. Review the lecture notes and textbook on safety inventory.

After reading through the instructor's email, textbook, and lecture notes, our group was able to set up an approach to safety inventory by first laying out the variables that we need to define before being able to solve for the necessary safety inventory level.

2. Answer each question in part A of the problem separately:
    a. Why should we have a safety inventory?

We, Text.book, should have a safety inventory in order to prevent the situation of running out of stock before the replenishment order arrives. With a high IDU, the amount of products sold would vary from week to week. Safety inventory is defined as the excess amount of inventory that is available after every replenishment cycle. I would highly suggest this for our company since there is always uncertainty around how many units we will actually be selling in the future, no matter how accurate our forecast is. By having more inventory than needed, the leftover units can be used up when the demand is high.

    b. What is the average weekly demand for our product?

In order to calculate the average weekly demand for our product in 2018, we simply divide the forecasted annual demand by 52:

Weekly demand =1,499,004/52 = 28,827

The average weekly demand comes out to **28,827 units.**

    c. What is the standard deviation in the weekly demand?

The standard deviation in the weekly demand can be calculated by taking the average weekly demand among each quarter separately. Since we have our mean weekly demand as 179 units, we can find the standard deviation by squaring the difference between the mean and the average weekly demand of each quarter in the year, dividing by the number of quarters, and then square rooting the whole value. The formula is as follows:

$$Standard\ deviation\ of\ weekly\ demand\ = \sqrt{\frac{1}{N}\sum_{i=1}^{k}(x_i - \mu)^2}$$

For 2018, the standard deviation in the weekly demand came out to be around **8,667 units.**

3. Answer each question in part B of the problem separately:
    a. What is the necessary safety inventory level to reach our desired CSL of 0.95?

In our case, we are first making the assumption that we have a lead time of 2.40 weeks. With the desired CSL, safety inventory can be calculated by the following formula:

$$ss\ =\ \sqrt{L} * \sigma_L * F^{-1}(CSL)\ = \sqrt{2} *\ 8,667 * 1.645\ = 22,153.93\ =\ 22,154\ units$$

Result: text.book should have a necessary safety stock level of $22,154$ units for a continuous replenishment cycle during the year 2018 with a lead time of 2.4 weeks.

    b. What is the ROP?

The Re-order point can be calculated by adding the expected weekly demand and the necessary safety stock:

$$ROP\ =\ ss\ + D_m = \ 21,154\ +\ 8,667\ =\ 29,821$$

Result: We should have a re-order point at **29,821 units** of inventory.

c. What is the fill rate?

Since our desired CSL is assumed to be 0.95, the z-score that corresponds to that level (1.645) can be used to determine the expected shortage cycle (ESC) before computing the fill rate.

Fill rate can be computed through the following equation:

$$fr = \frac{Q_L - ESC}{Q_L}$$

The above ESC value can be determined by the following:

$$ESC = -ss[1 - F(z)] + \sigma_D f(z)$$

The probability density function in the above equation was calculated to be 0.10. Therefore, we can compute the following:

$$ESC = -22,154[1 - 0.95] + 8,667 * 0.1 = 241$$

Now fill rate can finally be determined by using the calculated optimal lot size from previously:

$$fr = \frac{20,000 - 241}{20,000} = 0.988$$

Result: Our company would manage to achieve a fill rate of **98.8 percent,** indicating that 98.8 percent of customer demand can be fulfilled from available inventory during replenishment cycle.

d. What is the average inventory?

Average inventory, also known as cycle inventory, was calculated previously as **10,000 units** held during the year.

e. What is the average flow time?

To find average flow time, the replenishment cycle time must be calculated. Since we computed the values for replenishment cycle time in the cycle inventory section, we can use the value for 2018 from the Excel table:

Replenishment cycle time = 4.19

Thus average flow time can be calculated as the replenishment cycle time divided by 2, giving us a value of 2.1.

Result: The average amount of time that 1 unit of supply is held in inventory is around **2 days.**

4. Create a diagram that shows all the relevant quantities from part B.

Safety inventory can be depicted in a graph along with the relevant quantities calculated earlier in step 3.

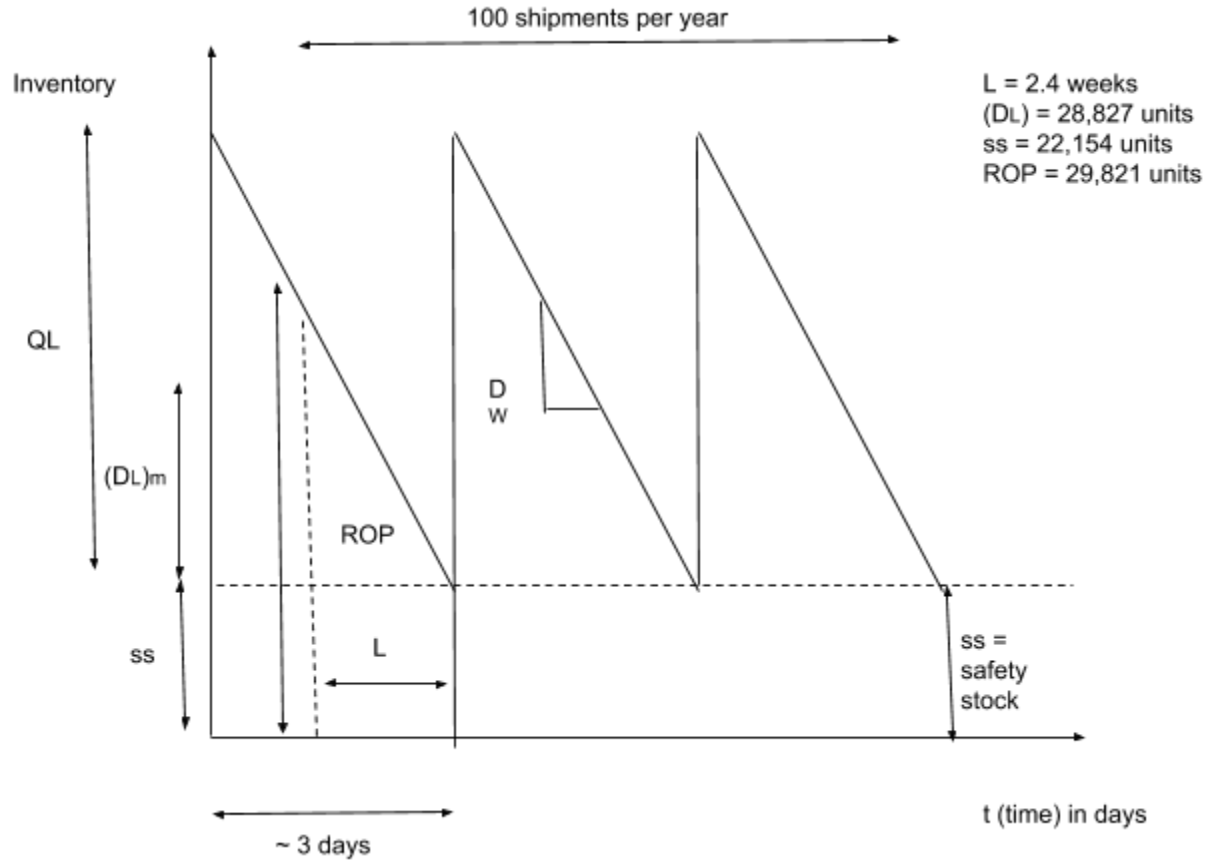


Figure 9.5: Cycle and Safety Inventory for 2018

Explanation: The above graph shows the various quantities calculated in the previous step. The y-axis represents inventory (lot size, safety stock, weekly demand) and the x-axis represents time (replenishment time, lead time). Cycle inventory is shown as the repetitive triangular shaped model above the dotted horizontal line. The length between the dotted horizontal line and the x-axis is the safety stock, measured as 22,154 units. The optimal lot size stands at around 20,000 units, with demand during lead time equaling 28,827 units.

Lot size is expected to deplete over the course of the replenishment cycle time of around 14 days before a new order arrives. The re-order point (ROP) is reached when the amount of inventory is at 29,821 units. In total, there are an estimated 100 shipments during the year by having a replenishment cycle time of 3 days.

The safety inventory data for each year is presented below:

Year	Month	Period	Demand	Quarterly Demand	Average Weekly Demand	Annual Demand	Mean Weekly Demand	Difference in Demand Squared	Standard Deviation	Lead Time	Demand During Lead Time	Std. Dev	Safety Stock 95% CSL	Safety Stock 99% CSL
1	January	1.00	185,667		42,846.23		42,807.75	1,480.77						
	Februar	2.00	185,667		42,846.23		42,807.75	1,480.77						
	March	3.00	185,667	557,001.00	42,846.23		42,807.75	1,480.77						
	April	4.00	254,667		58,769.31		42,807.75	254,771,323.96						
	May	5.00	254,667		58,769.31		42,807.75	254,771,323.96						
	June	6.00	254,667	764,001.00	58,769.31		42,807.75	254,771,323.96						
	July	7.00	154,667		35,692.38		42,807.75	50,628,424.56						
	August	8.00	154,667		35,692.38		42,807.75	50,628,424.56						
	Septem ber	9.00	154,667	464,001.00	35,692.38		42,807.75	50,628,424.56						
	October	10.00	147,000		33,923.08		42,807.75	78,937,415.68						
	Novemb er	11.00	147,000		33,923.08		42,807.75	78,937,415.68						
	Decemb er	12.00	147,000	441,000.00	33,923.08	2,226,003.00	42,807.75	78,937,415.68	16,978.04	3.00	128,423.25	29,406.84	48,521.28	83,809.48
2	January	13.00	168,333		38,846.08		37,615.38	1,514,603.56						
	Februar	14.00	168,333	504,999.00	38,846.08		37,615.38	1,514,603.56						
	March	15.00	168,333		38,846.08		37,615.38	1,514,603.56						
	April	16.00	220,667		50,923.15		37,615.38	177,096,721.90						
	May	17.00	220,667	662,001.00	50,923.15		37,615.38	177,096,721.90						
	June	18.00	220,667		50,923.15		37,615.38	177,096,721.90						
	July	19.00	132,000		30,461.54		37,615.38	51,177,514.79						
	August	20.00	132,000	396,000.00	30,461.54		37,615.38	51,177,514.79						
	Septem ber	21.00	132,000		30,461.54		37,615.38	51,177,514.79						
	October	22.00	131,000		30,230.77		37,615.38	54,532,544.38						
	Novemb er	23.00	131,000	393,000.00	30,230.77		37,615.38	54,532,544.38						
	Decemb er	24.00	131,000		30,230.77	1,956,000.00	37,615.38	54,532,544.38	14,602.78	2.70	101,561.54	23,994.81	39,591.43	68,385.20
3	January	25.00	143,333		33,076.85		32,692.27	147,899.41						
	Februar	26.00	143,333	429,999.00	33,076.85		32,692.27	147,899.41						
	March	27.00	143,333		33,076.85		32,692.27	147,899.41						
	April	28.00	176,333		40,692.23		32,692.27	63,999,384.62						
	May	29.00	176,333		40,692.23		32,692.27	63,999,384.62						
	June	30.00	176,333	528,999.00	40,692.23		32,692.27	63,999,384.62						
	July	31.00	120,667		27,846.23		32,692.27	23,484,088.77						
	August	32.00	120,667		27,846.23		32,692.27	23,484,088.77						
	Septem ber	33.00	120,667	362,001.00	27,846.23		32,692.27	23,484,088.77						
	October	34.00	126,333		29,153.77		32,692.27	12,520,982.25						
	Novemb er	35.00	126,333		29,153.77		32,692.27	12,520,982.25						
	Decemb er	36.00	126,333	378,999.00	29,153.77	1,699,998.00	32,692.27	12,520,982.25	8,666.85	2.40	78,461.45	13,426.62	22,153.93	38,265.88

Figure 9.6: Safety Inventory

The table above shows the weekly demand for each year. We got the values for standard deviation by taking the average demand of each quarter and then taking the difference between the mean computed. This procedure was performed due to the inability to find actual weekly demand data for our product. The only data we could find was the quarterly data which we used to best estimate the weekly historical data. We can calculate safety inventory for future years as long as we have an estimate of the demand for those years.

Conclusion: For the year of 2018, the necessary amount of safety inventory is measured to be 22,154 units after every cycle. A re-order point of 29,821 units indicates that the next order should be executed in order to ensure that we do not use the safety stock for our regular

shipments. By calculating safety stock, we were able to determine that our fill rate is 0.988 with a desired CSL of 0.95, which means that 98.8 percent of customer demand can be fulfilled from available inventory during each replenishment cycle. Now that we have information regarding our cycle and safety inventory, we can use that to determine our total annual transportation costs, which will be discussed in a later section.

**Note: The software automation can be performed as shown in the user manual in later sections.

Section 10.0 Facilities

10.1 Benchmark Plantronics' supply chain network against our supply chain

a. Plantronics' supply chain network:

i. PLT manufacturers 75% of their own products

ii. PLT buys raw material to forecast

iii. Assemble to min-max settings

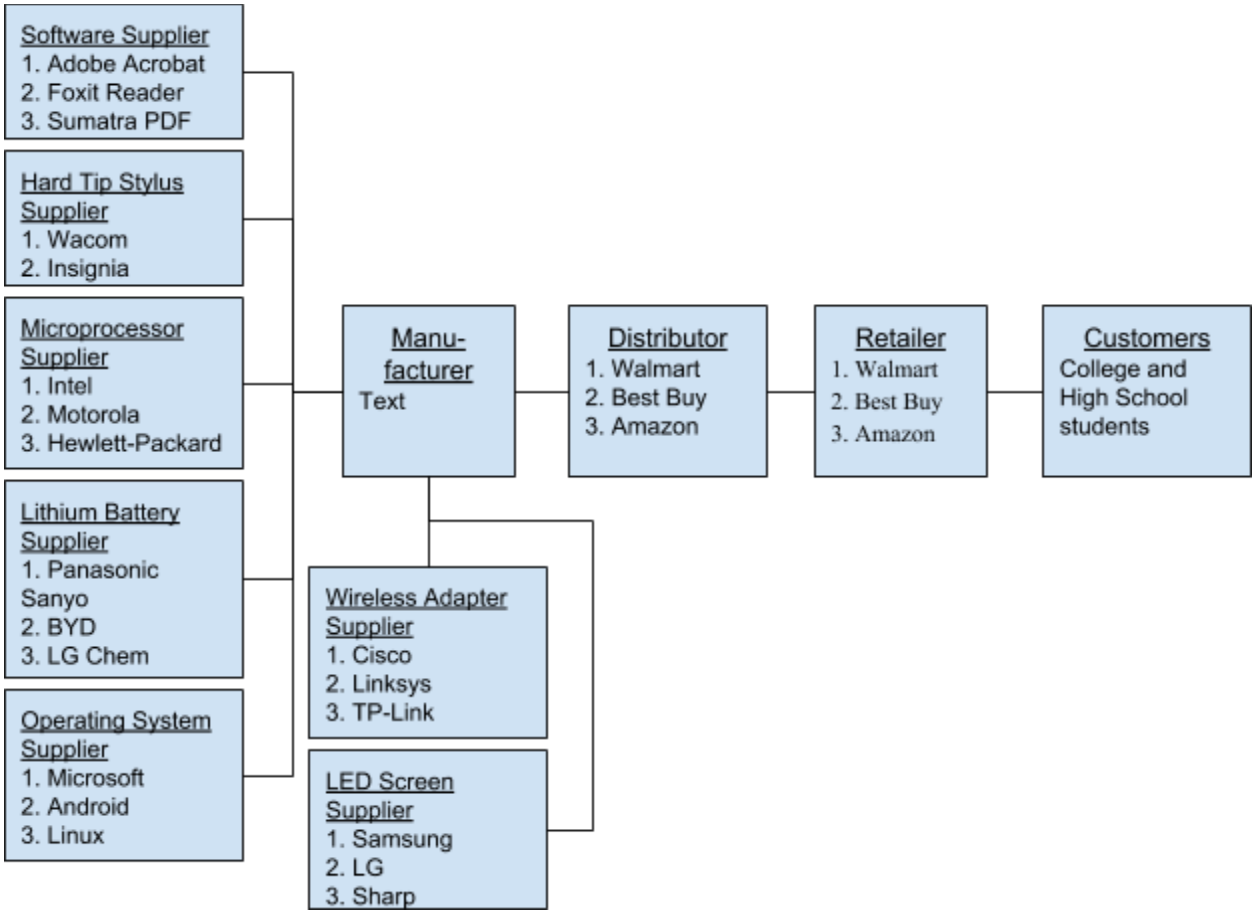
iv. Pack to order

v. Fulfill orders through distribution centers

vi. Decentralized purchasing and planning

Plantronics aims to increase their supply chain efficiency by automating information. This means being demand driven, globally focused, have a virtual supply chain, decision based and lean practices. Ultimately they want to create quick responsiveness and real-time collaboration built by better Information flow to increase forecast accuracy.

b. Text.book's supply chain network



Analysis: From analysing PLT's and our own supply chain network, we came to these conclusions:

In Text.book's supply chain network:

We can see that starting from the right are the customers and targeted market are primarily students. Customers can buy our product from a retailer such as Walmart, Best Buy, and Amazon. The manufacturer would be our company Text.book. We then pull the supplies for our product from several suppliers based on our listed subsystems above.

In PLT's supply chain network:

We can see that PLT is working on a big scale because they target companies not individuals. Even through they do provide audio devices for individuals, the majority of their money comes companies that buy large amounts of their devices. By manufacturing their own product they are able to produce when orders are placed.

Facility Design Framework:

I. Design a Supply Chain Strategy/Design

A. Determine stages in the supply chain (In-house or outsourced)

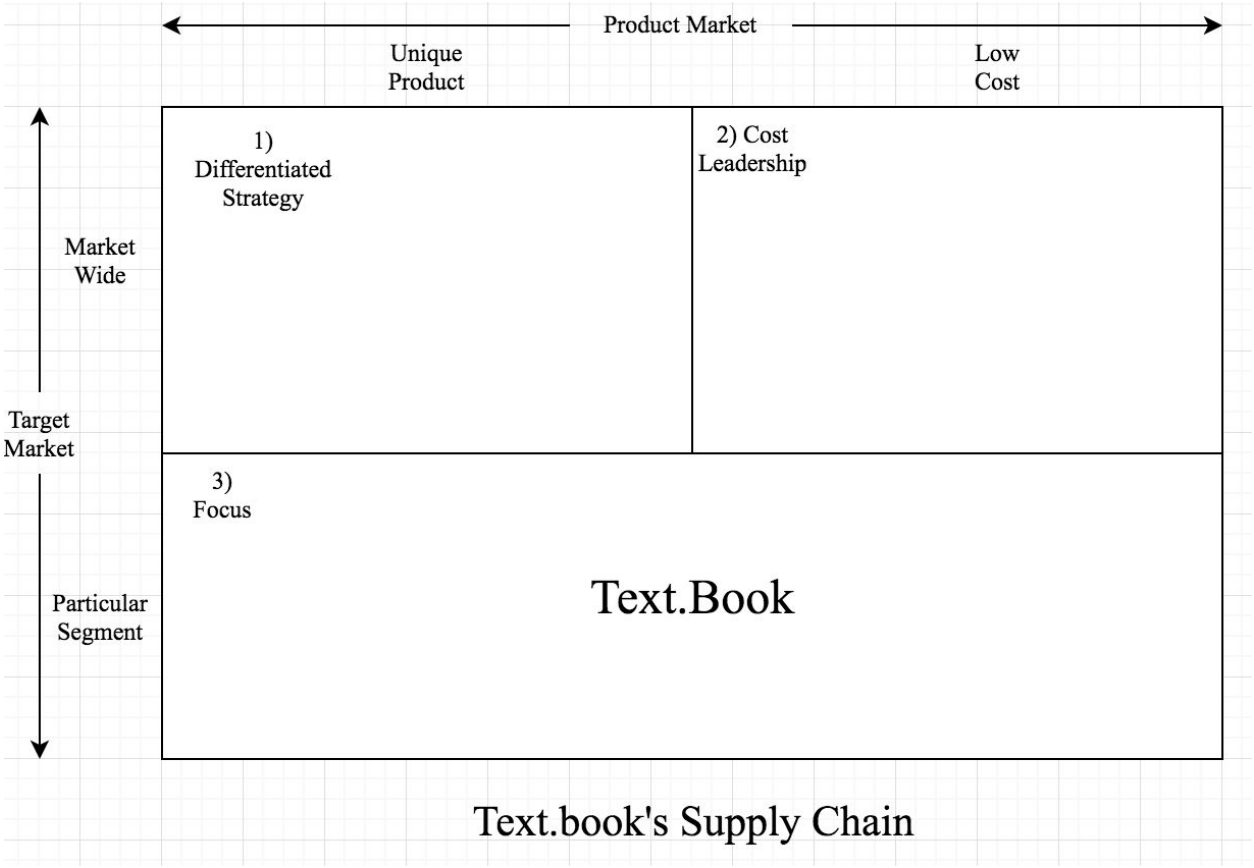
i. Our current supply chain consists of 4 key drivers which connect with each other to create a high-level supply chain network

1. Inventory: Raw materials; work in progress (manufacturing); finished goods (outsourced)
2. Facilities: Places where inventory is stored or manufactured/assembled (in-house)
3. Transportation: Movement of inventory from one facility to another (outsourced)
4. Information: Refers to all the data and analysis regarding inventory, facilities, and transportation; also includes management and coordination of info/data (in-house)

B. Clear definition of competitive strategy

i. Our product's (Text.book) defining features involve being the cheapest option for textbooks for everyone as well as being the newest product on the market. Therefore, on the Product/Market diagram, our product falls into the Focus section of the competitive strategy, as we have the newest

product, and a particular segment of the market (students and teachers/professors) to buy our ereader

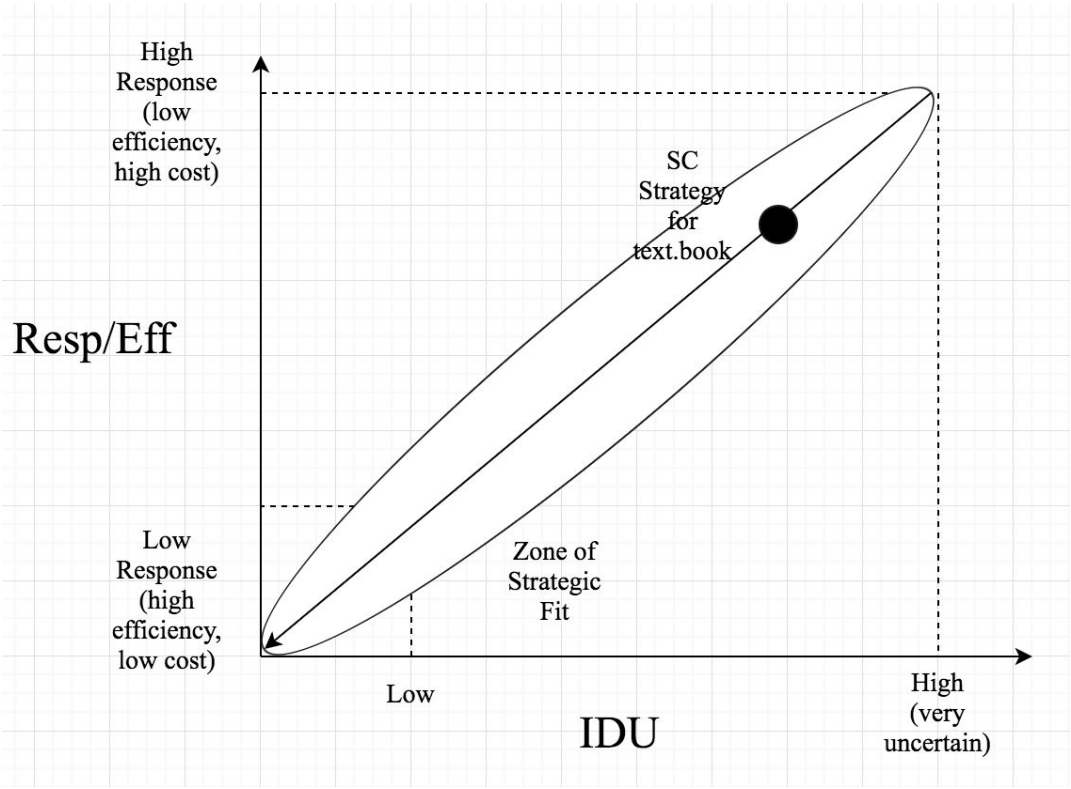


Text.book's Supply Chain

C. Capabilities that the supply chain must have to support the competitive strategy

i. To create cohesiveness in our supply chain to support our competitive strategy, our supply chain must involve a closed loop of information to prevent stockouts or increased customer demand from ruining Text.book's revenue or customer base. By mapping our zone of strategic fit on the IDU and Resp/Eff spectrum, we can expand it at any given time to match customer demand as well as our future goals

Text.book's Zone of Strategic Fit



II. Define Regional Facility Configuration

D. Identify regions where facilities will be located/roles/capacity

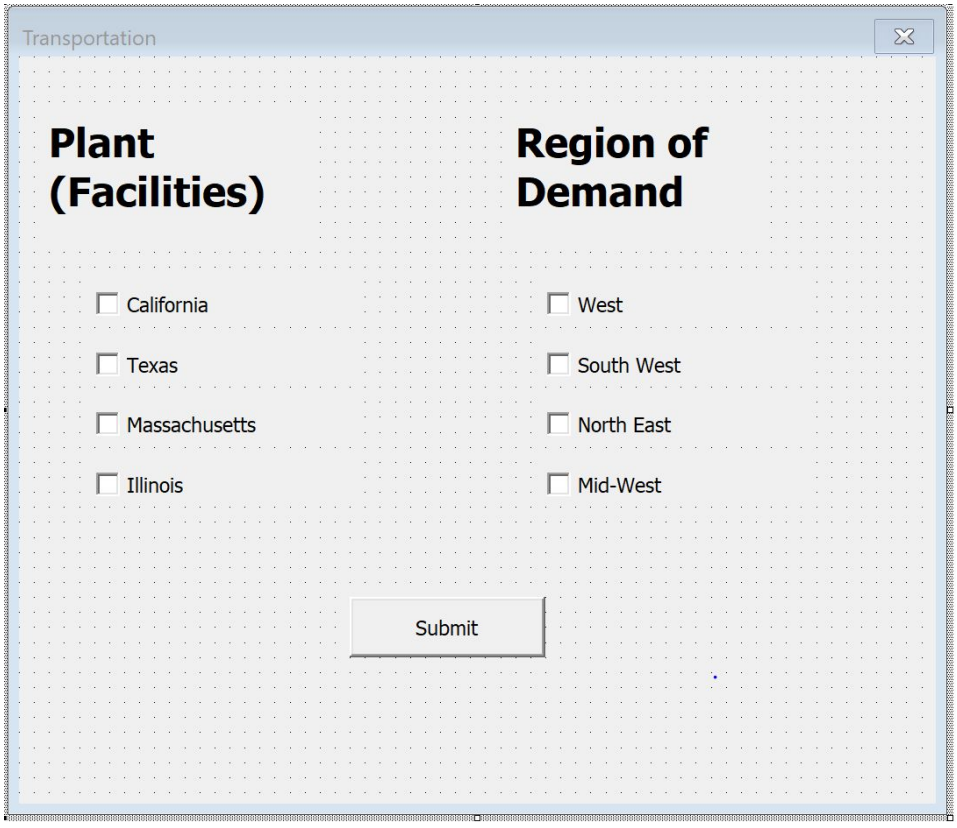
- In order to create the automated facilities, our company must conduct the following steps:

    - Learn Visual Basic and create the buttons

- The first step for determining the locations is to learn how to implement Visual Basic. From here, we can develop a GUI accessible to our company shown below …

10.2 GUI

Text's GUI



- The Transportation automation will take the checked boxes and determine the optimized cost given our constraints. By doing this, it will take the minimized cost of supplying to

the region, given the facility and constraints, from which we can add up

10.3 Capacitated Plant Location Model

- Find the inputs for the Capacitated Plant Location Model
  - From here, we can locate the Regions of Demand by:
    - Our team decided to split our distribution into 4 regions (West, Southwest, Midwest, and Northeast). In this case, we decided to ship to these regions, they would be grouped together in such a fashion that would make sense for distribution. The second step would be to research the top 10 most populated states in the US shown below …
    - Doing research on the most populated locations of college students in the United States (Top 10)

(https://www.citylab.com/equity/2016/09/americas-biggest-college-towns/498755/)

- California
- New Mexico
- Massachusetts
- New York
- Texas
- Florida
- Virginia
- Minnesota
- Illinois
- Washington

- Locating Primary locations for the facilities:

  - Find the most reasonable location (preferably the middle of the demand region to minimize costs)
  - To decide on the primary location for the facilities, our team looked into the most populated regions, and placed into the most appropriate facility locations. We do this to create a very well spread out and centralized facilities so that we can minimize transportation costs in any direction

  - Given the information above, we can determine that the most appropriate place to put these facilities are

Region	**Facility (By State)**

West	California
South West	Texas
North East	Massachusetts
Mid-West	Illinois

- Calculate the Operating Fixed Costs and the Variable Costs

    - In order to calculate the Variable Costs, our team followed the steps shown below
        - Material Cost - Estimated by doing research on similar parts
            - From doing research on parts of our e-reader, our team was able to estimate the following values by estimating a wholesaler discount of 5%
        - Manufacturing Cost - Given in our Financial Statement
            - Our manufacturing cost was calculated earlier in our financial statement as $40 per unit
        - Inventory Holding Cost - Given in our Financial Statement
            - Our inventory holding costs were calculated in our financial statement as $0.10 per unit

Section 11.0 Transportation

- Transportation Cost - Since this one is variable depending on facility location, we took several steps to estimate the most that the transportation cost would be from each demand region
    - The first step into calculating transportation costs was to do research on transportation costs per mile. This would give us a good estimate of how much it would cost us to transport our product both to and around the region. Our mile cost was taken from https://www.dat.com/industry-trends/trendlines/van/national-rates, where the following values were given in our National Trend Line:
    - National Trendlines

Regions	**Per Mile Cost**
West	$2.15
South West	$1.87
North East	$2.08
Mid-West	$2.64
National Average	**$2.14**

    - From the information shown above, we can then estimate within each region to estimate how far out delivery distance is by using the Gravity Location model (from textbook example chapter on transportation) Our team decided on this because it is the shortest route given the length and the width of the demand regions. This will minimize costs in the region and give us the maximum that will be spent on transportation costs within the region. The within region distances are

shown from (West x West), (Mid West x Mid West), etc. in the distance table shown below in distance in regard to miles:

Distance (Miles)	**West**	**Mid-West**	**South West**	**North East**
West	452	1152	1161	2240
Mid-West	-	639	640	1092
South West	-	-	1028	1226
North East	-	-	-	1325

- The last step is to take the per mile costs and multiply it by both the distance between the facility location, and the distance within the region. We multiply the distance between facility locations by the national average, whereas we multiply the per mile cost by region by the transportation costs within the region. Once we have these two values, we can add them up to find the transportation costs shown below:

Transportation Costs				
	West	Mid-West	South West	North East
West	**831.68**	3093.12	3433.1	5907.8
Mid-West		**1226.88**	2589.08	4048.04
South West			**1552.28**	4265.12
North East				**2279**

- We can see from the table above that we get the lowest transportation costs by operating within the regions, but it doesn't tell us much until we find the fixed operating costs of our facilities
- We can see from the table above that we get the lowest transportation costs by operating within the regions, but it doesn't tell us much until we find the fixed operating costs of our facilities.
- These transportation costs will be factored into the shipments per year by finding what percentage of overall agriculture is demanded per state. This will give us a weighted average of demand where we will then factor in transportation costs. We first need to estimate how much demand per region. We do this by taking the population statistics. We can then group the regions and add up the percentages and multiply the total demand for these states with our forecasted total demand
- We estimated the demand per region with statistics from this link (https://www.citylab.com/equity/2016/09/americas-biggest-college-towns/498755/) and ended with results below.

Rank	State	Amount of Attendees	Average Undergraduate Tuition and Fees
1	California	2,702,000	$13,900
2	New Mexico	36,855	$7,183
3	Massachusetts	346,157	$11,670
4	New York	1,057,288	$17,040
5	Texas	572,922	$7,166
6	Florida	308,348	$4,438
7	Virginia	21,095	$11,933
8	Minnesota	88,862	$8,467
9	Illinois	502,189	$9,199
10	Washington	293,391	$7,782

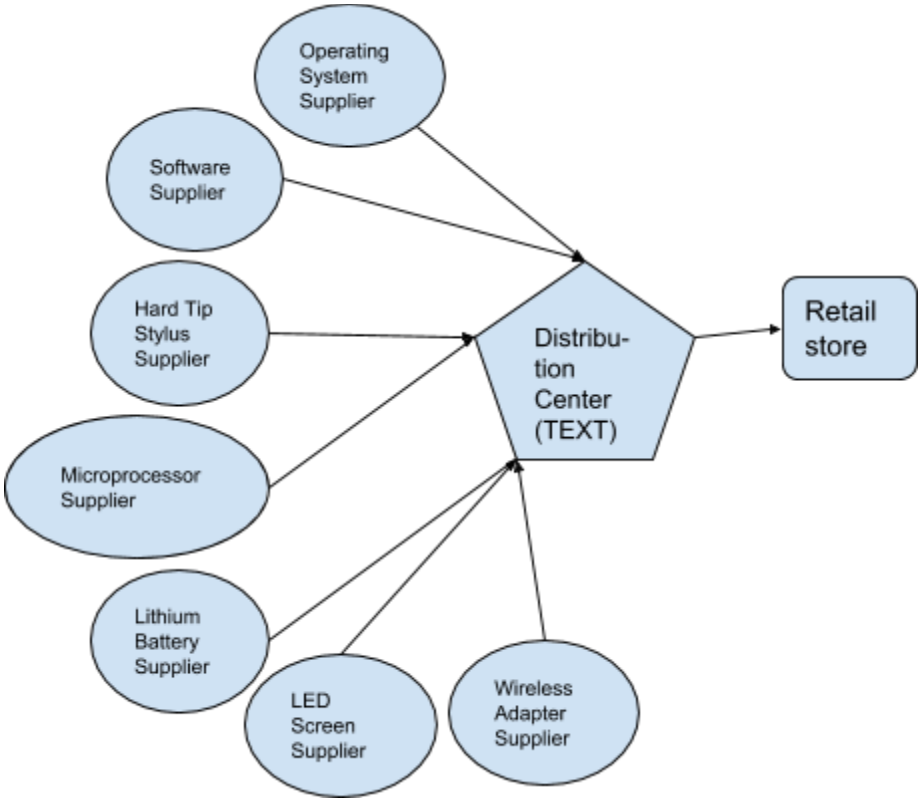
- We gathered the estimated amount of college students in each state and the amount of money each college student pays on average during 2017 school year.

- Result: As you can see California and Massachusetts would be our targeted states.

Regions	Value	% of share
West	2,738,855	0.594
South West	902,365	0.196
North East	884,442	0.192
Mid-West	88,862	0.019
Total	4,614,524	

- We added all the amount of college students in each state depending on region. To find the predicted demand percentage by dividing the amount of students in each region by the total amount of students in the top 10 states for college.
- Results: West coast region has the highest percentage from the four regions listed above. We decided we will focus West Coast.

- III. Transportation Network
  - Design a Transportation Network
    - Transportation network with a centralized network shipping via Central Distribution Center



- We decided that we would use centralized network shipping via Central Distribution Center. We choose this type of transportation network because we are in charge of manufacturing and distributing the product. It came clear to us to have a mode of transportation from supplier to Text.book and from Text.book to retail stores.

- Trade-offs in Different Transportation modes
  - Ranking of Transportation modes in terms of Supply Chain Performance

Size	Lot Inventory	Safety Inventory	In-transit Cost	Transportation Time	Transportation
Rail	5	5	5	2	5
TL	3	3	4	4	4
LTL	1	2	3	3	2
Air	2	1	1	5	1
Water	4	4	2	1	3

- Transportation Proposals for Text.book
  - The impact of using different modes of transportation on inventories, response time, and costs in the supply chain is shown above. Each

transportation mode is ranked along various dimensions, with 1 being the worst and 6 being the best.

Carrier	Range of Quantity Shipped (cwt)	Shipping Cost
XPOLogistics	500+	$5.25
Hub group	400+	$6.50
Swift Transportation	300+	$7.00
YRC Worldwide	100-300	$8.50
TransForce Inc.	200+	$9.00

- We looked up the shipping cost of 5 different carriers and their range of quantity that can be shipped. We chose these 5 different carriers because they had good reputation and were in the top 50 LTL list.

https://www.joc.com/trucking-logistics/top-50-trucking-companies-2012

- Analysis of Transportation options for Text.book

Alternate	Lot Size	Transportation Cost	Cycle Inventory	Safety Inventory	In-Transit Inventory	Inventory Cost	Total Cost
XPOLogistics	5,000	$656,250	2,500	1,027	1,712	$78,596	$734,846
Hub group	4,000	$812,500	2,000	1,027	1,712	$71,096	$883,596
Swift Transpo	3,000	$875,000	1,500	1,027	1,712	$63,596	$938,596
YRC Worldwi	1,000	$1,062,500	500	1,027	1,712	$48,596	$1,111,096
TransForce Ir	2,000	$1,125,000	1,000	1,027	1,712	$52,356	$1,177,356

- The list of formulas for the columns from lot size to total cost:
    - Lot Size:
        - Is equal to the range of quantity shipped
            - For XPOLogistics example:
                - Q = 5,000
    - Transportation Cost:
        - Transportation Cost = Demand *Shipping Cost
            - For XPOLogistics example:
                - Transportation Cost = 125000*5.25
                - Transportation Cost = $656,250
    - Cycle Inventory:

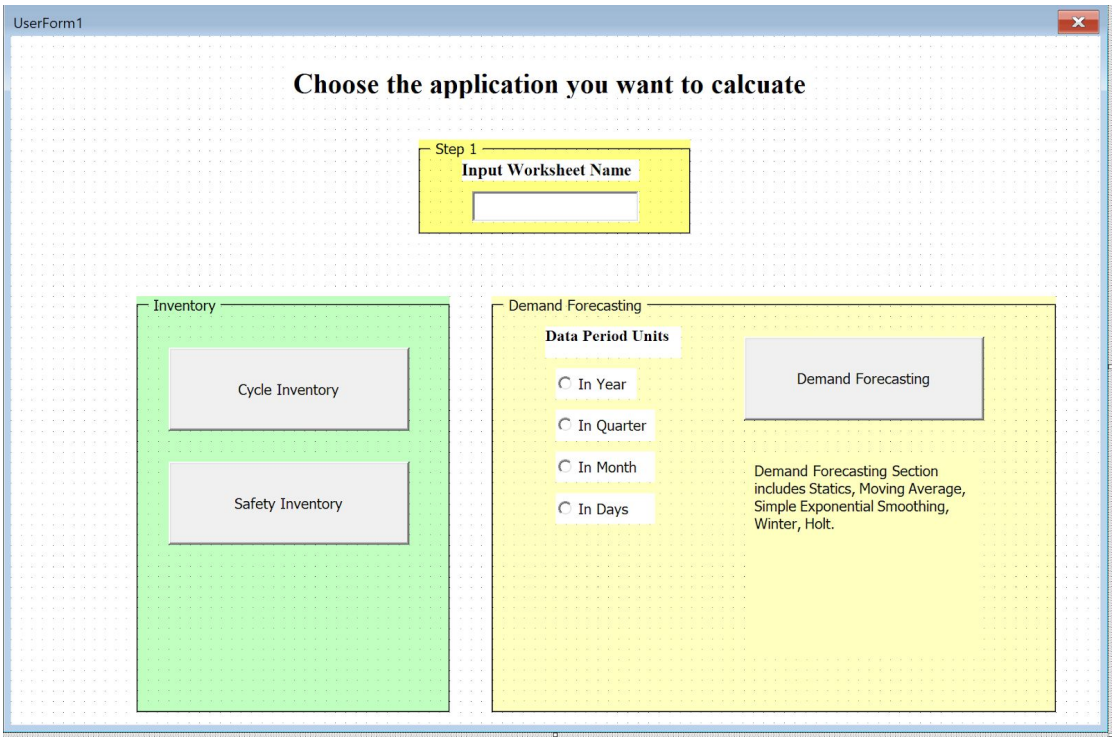
- Cycle Inventory = (Lot Size)/2
    - For XPOLogistics example:
        - Cycle Inventory = Q/2
            - Cycle Inventory = 2,500
- Safety Inventory:
    - Safety Inventory = (L/2)*(Demand*Shipping Cost)
        - For XPOLogistics example:
            - Safety Inventory = (6/2)*(125,000/365)
                - Safety Inventory = 1,027
- In Transit Inventory:
    - In-Transit Inventory = (Demand)*(5/365)
        - For XPOLogistics example:
            - In-Transit Inventory = 125,000*(5/365)
                - In-Transit Inventory = 1,712
- Inventory Cost:
    - Inventory Cost = (Cycle Inventory + Safety Inventory + In-Transit Inventory) * H
        - H = h*C
            - For XPOLogistics example:
                - Inventory Cost = (2,500+1,027+1,712)*(15)
                - Inventory Cost = $78,596
- Total Cost:
    - Total Cost = Inventory Cost + Transportation Cost
        - For XPOLogistics example:
            - Total Cost = 163,719 + 656,250
                - Total Cost = $819,969

- Results:
  - Once all the calculations were done as shown in the chart above, we will be going with carrier XPOLogistics to be the mode of transportation. XPOLogistics provides the service needed at the minimal cost.

Section 12.0 User Manual

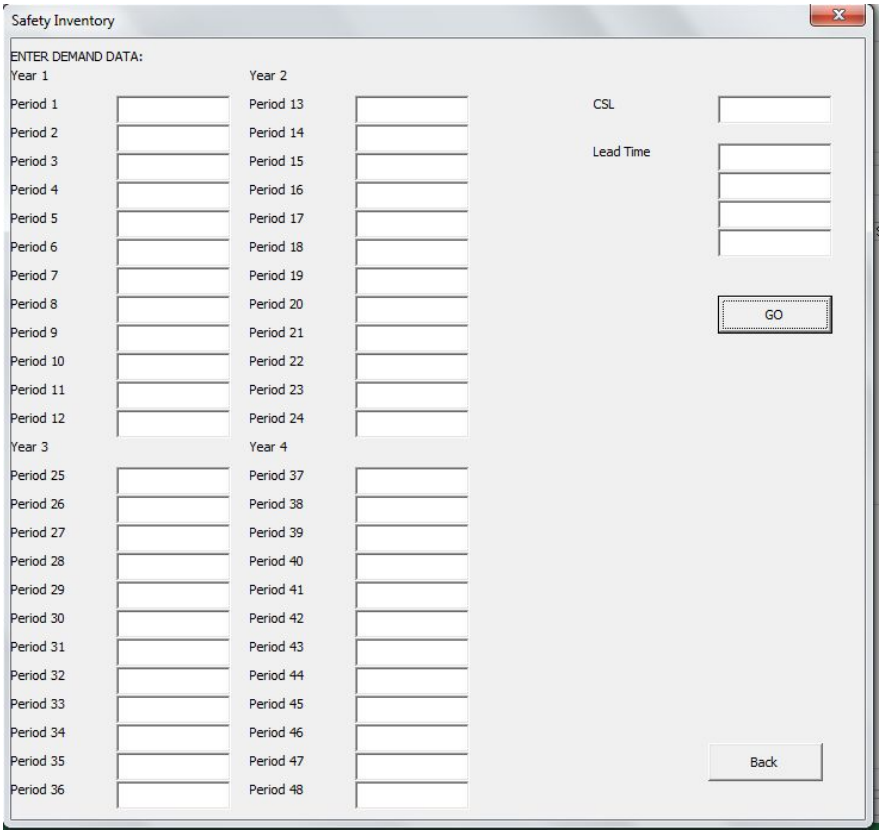
12.1 Main page User Manual

- This program is like a organized main pages that allows users to choose which next program they want to choose. We have Inventory section and Demand Forecasting section.



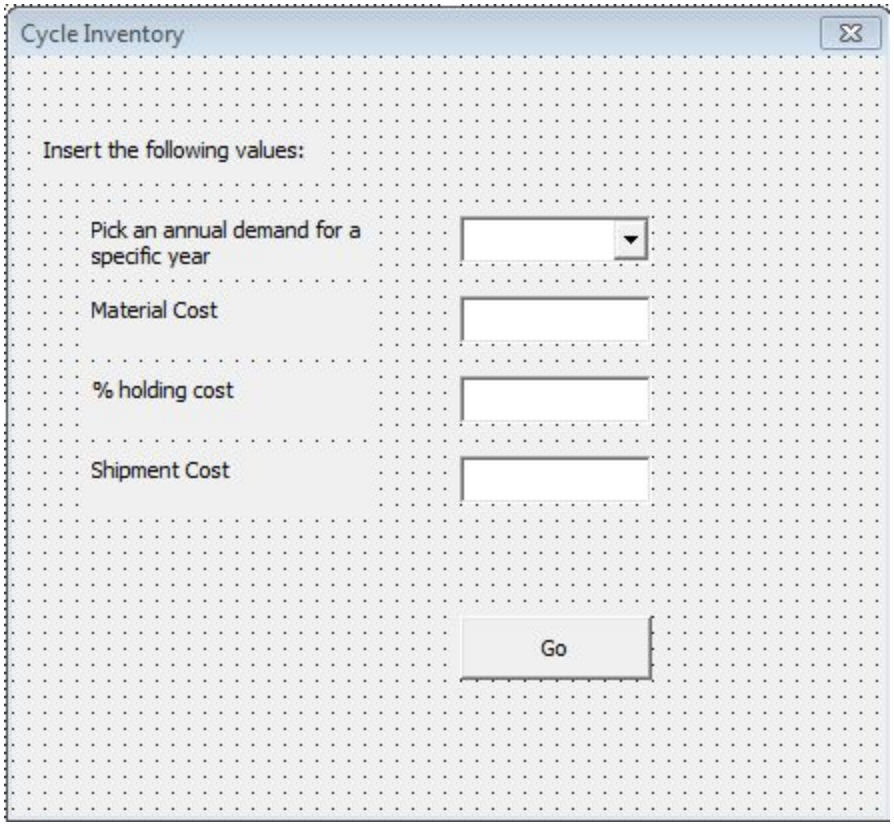
12.2 Safety Inventory User Manual

- This basic model will begin by taking demand data, lead time, CSL.
    - Main Page (data entry):
        - Input demand data for four years
        - Choose desired CSL level
        - Choose lead times.
        - Click “Go” to see the results
        - Click “Back” to go back to main page



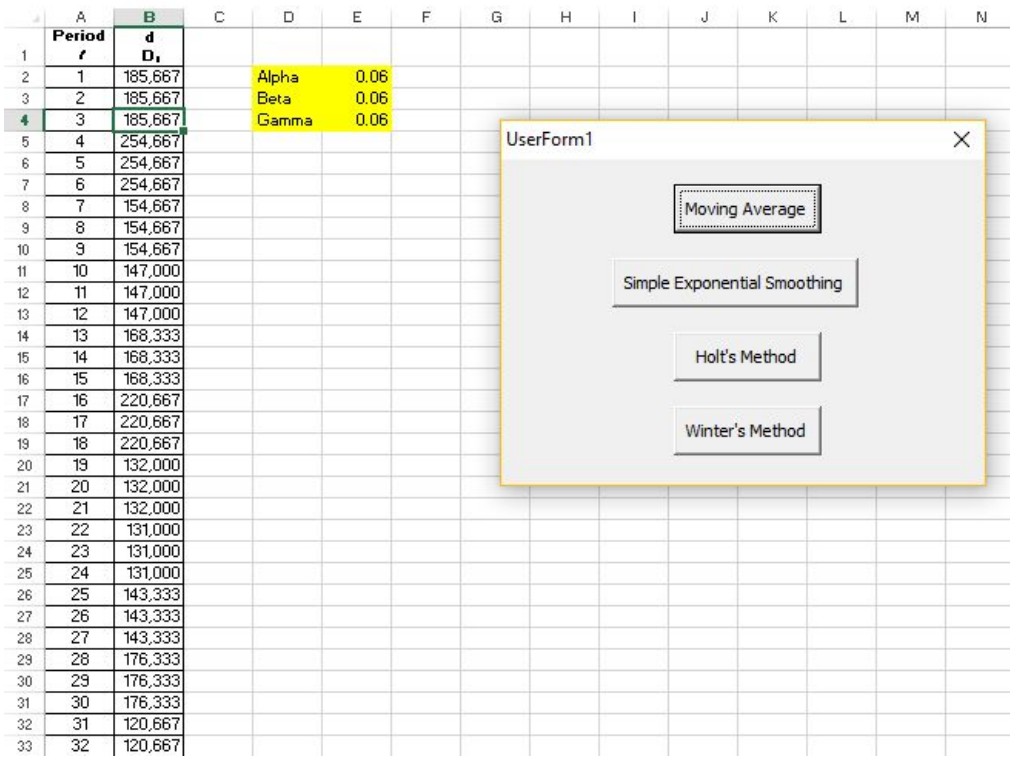
12.3 Cycle Inventory User Manual

- The program for Cycle Inventory will be implemented using the simple GUI referenced in the cycle inventory calculations. The basic model will begin by prompting the user to input a set of variables such as annual demand, material cost, percent inventory holding cost, and shipment cost. Clicking the “Go” button will bring up an excel spreadsheet with all the cycle inventory calculations
    - Main Page (data entry):
        - Pick an annual demand for a specific year
        - Choose the material cost
        - Choose the percent holding cost
        - Indicate the cost for shipping
        - Click “Go” to see the results



12.4 Demand Forecast User Manual

- The user is prompted to enter all necessary demand data in a column
    - If needed, the user can click the highlighted text boxes to change the values of the smoothing constant variables
    - In the GUI, click the button that corresponds to the desired forecasting method.
        - Moving Average
        - Simple Exponential Smoothing
        - Holt's Method
        - Winter's Method
- After clicking on the forecast method, notice the new forecast appears in the method



Period t	d D_t
1	185,667
2	185,667
3	185,667
4	254,667
5	254,667
6	254,667
7	154,667
8	154,667
9	154,667
10	147,000
11	147,000
12	147,000
13	168,333
14	168,333
15	168,333
16	220,667
17	220,667
18	220,667
19	132,000
20	132,000
21	132,000
22	131,000
23	131,000
24	131,000
25	143,333
26	143,333
27	143,333
28	176,333
29	176,333
30	176,333
31	120,667
32	120,667

Section 13.0 Conclusion

Our company learned and mastered the important practical applications and theory of efficient supply chain management taught this quarter. We had an easy transition in designing a supply chain network by having a clear competitive strategy from last quarter.

The first step was doing research on the many drivers of a supply chain network starting with demand forecasting, then cycle and safety inventory, then plants and facilities, and ending with transportation design. As we began defining our drivers, we learned how difficult supply chain management is due to the required active cooperation and communication.

We estimated our historical demand based on our product life-cycle model, market analysis, and cash-flow analysis from last quarter. Based on our experience from other courses, we have a plan and idea of our software platform to manage the supply chain.

From the Supply Chain Strategy, we figured out that Text.book will be somewhat high responsive and IDU. From the Software Development Plan, the best choice will be to outsourcing all our software. From the Forecasting Demand, we figured out the demand will be 7.96 million, rate of growth will be 7.16 per year, and no seasonality.

We learned that as soon as one task was delayed, the whole network was delayed. Although we were all individually capable of completing exercises in relation to these drivers, coming together to apply the work to our group grew more complex over time. As a result, it is clear to see why the complexity of a supply chain produces high demand for automation of these drivers.

Section 14.0 Project Contribution

14.1 Pranav Lodha

Over the course of two quarters we have worked on our group project as a team. We have each put in multiple hours of effort, and especially this month we have spent a larger amount of time than we hand in the previous quarter. During this quarter I primarily worked on the financial information, along with the demand forecasting.

For the financial forecasting I worked on updating our demand and sales figures to match that based on the data that we had collected, and to update the total profit that we would generate based on our new demand data. This new demand data would also lead me to work on the demand forecasting.

As well as being in-charge of financial forecasting, I worked on the demand forecasting. I was able to build the excel file for the static forecasting, moving average forecasting, simple exponential smoothing forecast, holt's method forecasting, as well as winters method forecast. Finally, I was also in-charge of the automation of the demand forecasting, where I used visual basics to build the forecasting methods above to be completely automated.

Along with Eric, we both lead the tasks that the group would complete and if we were on schedule to complete the task. We were also in-charge of making sure that revisions were up to par of what Professor Desa wanted us to fix. Finally, I also oversaw the compilation of the final report and the completion of a two quarter long project.

14.2 Lemuel Chan

Working alongside my team member, Jun, I was able to curate and complete designing and implementing the Transportational Network and the Facilities. We created a plan for these new elements in Phase 3, and polished the execution of it upon meeting with Professor Subhas and having a more in depth understanding of the process from lectures. First, I benchmarked Plantronic’s supply chain network against Text’s supply chain and analyzed the differences and key takeaways from the comparison. Next, I added determine the stages in the supply chain and defined a clear competitive strategy with the capabilities it should have using the IDU and Responsiveness/Efficiency spectrum. We were able to define the regional facility configuration

using visual basics, with the help of Pranav, Eric, and Xiaochen. Jun and I found the inputs for the capacitated plant location model and Susana helped to calculate operating fixed costs and variable costs and provide the transportation network as well. Lastly, I created and tested the Demand Forecast User Manual with Pranav and Eric's implementation of the GUI. My contribution in the transportation network and facilities is fundamental to the overall project because we need to use this information to decide where we place our plants to create a more efficient supply chain.

In addition, I assisted my team on completing the backlog after meeting with the professor and taking his advice on what we need to improve on. I was able to inform the team members, who could not attend the Tuesday meeting that day, specifically what parts were missing or required to spend more time on in our project. Overall, I helped the team update and compile the overall work done to make sure everything is completed and properly organized.

14.3 Junyan Mak

Over the course of 10 weeks in TIM 125, with Professor Desa, our project team (Team 7) has worked through much of the beginning steps to our development of our new product, Text.book, an affordable e-reader geared towards college and high school students. As a team, we came together every week, and sometimes twice a week, and completed very good project work simultaneously to help develop the cohesiveness of our product. Individually however, I believe I helped contribute on several parts of this quarter long project to help the team finish in an efficient timely manner.

In the beginning of the quarter, much of my work was done in redefining our company's competitive as well as supply chain strategy. This was extremely important to our project as this set the basis for the work we would be doing throughout the quarter. I then moved on to working through the zone of strategic fit for our product, and determining how to maximize Text.book on the Resp/Eff spectrum. Throughout this, I was also in charge of creating these diagrams to help back up our information and make our project report easier to understand.

In the latter of the quarter, much of my work was done in tandem with group member Lemuel Chan. Since the facilities location and transportation costs were extremely in depth, it needed to be completed on a scheduled basis so that the other members could complete the

Visual Basic work needed to be done. This work included many equations and diagrams, as well as looking up on the internet the most populated regions and states of the United States, to effectively determine where to locate our warehouses, where we can also minimize transportation costs to maximize profits.

14.4 Susana Esparza

Contributed in:

1. Supply Chain:
    a. Dissected the product
    b. Found the subsystems
    c. Researched on the different suppliers for each sub-system
    d. Organized the information in a diagram
2. Transportation:
    a. Estimated demand per each region with statistics
    b. Researched on the number students in the United states in the top 10 states then separated the 10 states in the four regions.
3. Transportation network:
    a. Researched the different types of transportation
    b. Researched the different types of carriers
    c. Calculated the Analysis of transportation options for Text.book
4. I also involved in the little tasks for each phases like:
    a. Benchmarking the comparisons with Plantronics
    b. Organizing the information in the Phases

14.5 Xiaochen Zhang

Throughout the ten weeks on projecting the supply chain management system with group. Each of us have their own assigned part in every phase, then we meet again together to make sure we understand the whole phase.

In Phase 1 and 2, I contributed in Supply Chain Strategy as primanary, and I also be the helper of the other parts such as high-level structure for Text.Book supply chain, and I also

develop a high-level supply chain network for textbook. In Phase 3 and Phase 4, I am mostly the helper, since I have a really difficult time on learning VBA. I helped on manage the user manual for transportation and facilities. For the final project, I worked on Financial Analysis and Supply Chain Strategy to make sure both section have all materials that needs to be put, and make sure they are organized and done.

Overall, in this quarter, I am more as helper to our group. Which feel apologetic that not doing great on work as other groupmate.

14.6 Eric Walker

In terms of project tasks, I contributed to the following:

Supply Chain Strategy:

We discussed most of this as a team to really design the supply chain to the best of our abilities. As a team we made several revisions to this section based on feedback from both the professor and teaching assistants. In this section I helped research pre existing products on the market to see how they were taking on the market and used that information to help form our supply chain.

Inventory:

I was the leader of this section and had the help of Pranav. It didn't really make sense to have the whole team work on this section since it would be hard to work on one Excel sheet together. We used the lessons taught in lecture as well as previous Excel experience to complete this section. In addition to creating the Excel sheets, I also had to explain the thought process between all my calculations.

Software:

As a team we all learned how to use Visual Basic and afterwards split up the parts of our software to individuals. Getting used to creating modules in Visual Basic was a challenge and required a couple of meetings to really get going but we triumphed. Since this section was based off of our previously designed Excel sheets it made sense that I would work on the inventory portion of this section. For our software I was responsible for the cycle inventory, safety inventory, and part of the main page.

Looking at the project as a whole I feel that our team melded quite well together and nobody was really left behind. If someone didn't understand a concept or was stuck on a problem we always had someone there to work that team member through it.

14.7 Huiting Zhu

Over the course of Winter quarter, I worked together with my team and learned a lot.

For the whole team project in this quarter, we continued working on our company's products that we created in last quarter Text.book.

We worked and discussed together for the first two phase, so it could not separate clearly about the contribution. I gave many ideas and solutions when we struggled.

Actually, for the contributions listed in project plan, I worked most on the transportation and integration parts in this project. Also, In Section 4.0 Supply chain strategy, I made the table of customer needs, explained the details for it. In other parts, I just helped my groupmates to improve their parts based on professor feedback.

For the final report, I worked on the Section 6.0 and Section 7.0. I summarized, organized, and combined each parts together into the sections

Through back the ten weeks we spent together, I recognize myself still has much deficiency, but I am really appreciate with the help from my teammate, professor, and TA.