SAN JOSÉ STATE UNIVERSITY

THE XYZ PRODUCTS DIVISION PROJECT

Group-2

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Executive summary

To address operational challenges stemming from an unfortunate patent expiration, the XYZ division of AK Enterprise, located in Pleasanton, CA, under the leadership of Mr. John Smith, underwent a significant transformation of its manufacturing procedures. The nutritional product division grappled with heightened market competition, leading to persistent demand backlogs, elevated work-in-process inventory, and underutilization of machinery. Consequently, the division implemented advanced forecasting techniques such as exponential smoothing and Brown's double exponential smoothing. The goal was to enhance the accuracy of predicting product demands over the last five weeks, leveraging data collected over the preceding twenty weeks. These initiatives encompass aggregate planning, Material Requirements Planning (MRP), Master Production Scheduling (MPS), comprehensive capacity planning, and Simulation and scheduling. The overarching objective was to improve production operations, boost the fulfillment rates of demand, and implement cost-saving measures within the company. Through these strategic programs, the company positioned itself to strengthen its competitive edge in the rapidly evolving consumer goods industry and foster sustainable organizational growth. This marked a significant step towards reviving operational activities and ensuring profitability for the XYZ Division.

Introduction

1.1 Background

Located in Pleasanton, CA, the XYZ Division of AK Enterprise specializes in the production of nutritional items, including adult medical nutrition supplements and pediatric infant formulas. However, following the expiration of a patent, the division experienced a significant shift in its market dynamics. Analysis of the demand data from the last twenty weeks revealed that the XYZ Division historically sold its product line directly to distributors and wholesalers. This approach led to decreased profits, primarily due to persistent demand resulting in backorders, along with cost constraints in production operations. These constraints resulted from inadequate forecasting, inefficient machine utilization, and a lack of planning in scheduling. The prolonged operational inefficiencies further resulted in an accumulation of excessive work-in-process inventory, extending production durations.

1.2 The Problem Statement

The AK Enterprise's XYZ division faced a decline in profits due to operational inefficiencies. This resulted in numerous delayed deliveries, leading to widespread backorders within the organization. Additionally, the production facility grappled with the need for effective cost containment, characterized by high Work-in-Process (WIP) inventory levels and prolonged production cycle times.Several challenges stemmed from issues such as overproduction, incorrect assortments of product types, attributed to inaccurate forecasting, underutilization of machines, inadequate lot sizes, and the absence of a scheduling methodology. Over the years, this problematic environment created a pressing necessity for substantial operational adjustments, as the company's survival was at stake without them. Mr. John Smith, serving as an industrial engineering manager, took on the responsibility of addressing these issues. He focused on establishing a structured approach to demand prediction, aligning production with Bills of Materials (BOM) and capacity, and defining the types of products and optimal production times.

1.3 Objective

Serving as the Industrial Engineering Manager within XYZ, a department of AK Enterprise, Mr. John Smith took on the pivotal role of revitalizing the struggling operations of the division, which had been facing challenges in reaching profitability and exhibiting significant inefficiencies. A key element of this revitalization strategy involved constructing a precise forecasting model using contemporary methods. This encompassed analyzing past sales patterns and considering current economic conditions.Integral to this approach was the development of a production plan that aligned production requirements with anticipated demands, adhering to Bills of Materials (BOM) and adjusting capacity for different product types. The overarching strategy aimed to minimize stocks, enhance the utilization of existing resources, and streamline production processes. Additionally, the initiative embraced a systematic scheduling approach to optimize machine utilization and workforce management, to reduce production cycle times for swift product delivery to customers.This comprehensive operational overhaul is aimed at enhancing demand fulfillment efficiencies, controlling costs, and optimizing processes. The ultimate objective was to boost customer satisfaction and restore the profitability of the XYZ division.

Methods & Procedures

2.1 Overall General Plan

Based on the previous ten weeks of data, the aim was to produce a forecast for the following five weeks with a Mean Absolute Deviation (MAD) of less than 10 to validate the forecasting model. First, the most optimal approach must be chosen. This includes Naive, Moving Average, Exponential Smoothing, and Seasonal Model. Next, the selected model must be used to estimate demand and its compliance with the MAD must be verified. If the selected approach requires smoothing constants, alternative constant values are tested to find the best set. MAD is calculated as the average of the absolute errors, considering only the size of the error without the polarity.

2.2 Forecasting

Product 1

To see if our demand follows any trends or seasons, first, a line graph was plotted (Figure 1.1). The line graph indicates that demand was steady and did not follow any trends or seasons. Given the lowest Mean Absolute Deviation (MAD) was achieved using exponential smoothing with an alpha value of 0.1, this model was employed to forecast the project's demand for the next 5 weeks. The forecasted value for week 21 was calculated as 145 (refer to Table 1.1), assuming constant demand.

Product 2

After the 20-week observation period, it was clearly shown (Figure 2.1) that product 2 exhibited a seasonal demand pattern. The seasonal cycle recurs every nine weeks, and the anticipated values for weeks 21 to 25 were derived from a seasonal pattern (Table 2.1). These projected values were computed based on the latest levels, trends, and standardized seasonal indexes, resulting in a mean absolute deviation (MAD) of 3.06 (Table 2.2).

Product 3

The recurring seasonal demand pattern with a four-week cycle has been identified through our analysis, as illustrated in (Figure 3.1). We utilized various forecasting techniques, including Moving Average, Naïve Method, and exponential smoothing, to determine the most suitable Mean Absolute Deviation (MAD) of 3.29, as presented in (Table 3.2), achieved through the Linear Regression Model. To predict values for weeks 21 to 25, we employed both seasonality and trending methods, calculating the forecast with the aid of intercept and slope, and then multiplying the trend value found in the seasonality index for each week of 4 in 6 seasons. The resultant forecast, as demonstrated in (Table 3.1), aligns with the observed seasonality and trend.

Product 4

Figure 4.1 illustrates a discernible upward trend of Product-04 data. The forecasting for the period 21 to 25 was conducted utilizing the linear regression approach, as detailed in Table 4.1. The projected values were obtained using the parameters $\alpha = 0.2$ and $\beta = 0.4$. The intercept was used as our base forecast (F_t), and the slope was used as our trend value (T_t). Consequently, the methodology of linear regression was employed, with a focus on the most recent weeks based on the initial 10 weeks.

Product 5

The data for product 5 was plotted (Figure 5.1), and no seasonality or trends were discovered. Thus, exponential smoothing was used to create forecasts 21–25. The more recent data was given more weight using an alpha value of = 0.6, and calculations were made to get MAD below 10. (See Table 5.1).

2.3 Forecasting research

Method 1 – Horizontal Growth Rate Method

In addition to the primary forecasting methods, this study proposes four supplementary forecasting methods identified through an exhaustive investigation of journals. The first method is the Horizontal Growth Rate Method, also known as horizontal analysis, which is typically used to analyze and compare financial data over multiple periods to identify trends and growth patterns (Thomopoulos, 2014). However, it is not suitable for forecasting future demand, particularly the 5-week demand based on demand. Therefore, other techniques such as forecasting with seasonality and trend analysis might be more appropriate for estimating demand, especially when seasonality and trend components are involved, as observed in Product 2 and 3

Method 2 – Double Exponential Smoothing (DES) Brown's Model

Double Exponential Smoothing (DES) Brown's Model is a suitable method for forecasting data with a trend, making it a great fit for our seasonal demand data. Each week was carefully considered, and each method underwent testing to evaluate its potential for enhancing forecast accuracy. This technique is a "recursive" meaning it carries the error forward as forecast (Dharmawan & Indradewi, 2021). For each product, the Mean Absolute Deviation (MAD) was calculated using the equations of Brown's Double Exponential method (refer the tables in Appendix B).

Method 3 – Naïve 2 Model

The Naïve 2 method, also known as the Seasonal Naïve method, is well-suited for our data due to the observed seasonality in our product 2 and 3. This method is particularly appropriate for highly seasonal data as it sets each forecast equal to the demand from the same period in the previous season. Unlike the Naïve forecast, the Naïve 2 forecast takes seasonality into account by setting the forecast equal to the most recent observed value in the same season (Meyer, 2002). Therefore, the Naïve 2 forecast is especially suitable for highly seasonal data, as it bases the forecast on the corresponding period in the previous season, thus capturing the seasonal patterns effectively.

Method 4 – The Temporal Fusion Transformer (TFT)

The Temporal Fusion Transformer (TFT) is a cutting-edge model that uses machine learning to understand the intricate patterns in multiple time series data (Pfister, 2021). What sets TFT apart is its ability to handle various types of features, such as it provides interpretable predictions (Pfister, 2021), this means you can see why the model is predicting a certain level of demand and which factors are driving that prediction, allowing you to understand the importance of different variables and seasonal patterns in the forecasted demand.

2.4 Aggregate planning

A comprehensive aggregate planning solution has been developed for the upcoming five weeks, with a primary focus on aligning with projected demand while minimizing overall production costs. Over the planning span of five weeks and based on forecasted values, both level and chase production strategies were applied to each of the five product categories. As part of this analysis, a production rate of 30 units per worker per week is assumed, considering 480 manufacturing minutes in a day, a standard workweek of five manufacturing days, and a total of 52 working weeks in a year.

Level Strategy for Product 1:

The production rate was consistently set at 145 units per week, requiring 5 workers each week. Five of the ten available workers were terminated during the initial week. Both ending inventory and backlog were meticulously maintained at zero. Undertime units were consistently present, totaling 25 units over the span of five weeks. The overall production cost over this period amounted to $201,500 (Refer Table 7.1).

Chase Strategy for Product 1:

Production was dynamically adjusted to align with weekly demand, leading to the necessity of dismissing workers as needed. Similar to the level strategy, undertime units persisted each week, totaling 25 units over the five-week period. The cumulative production cost over five weeks reached $204,000 (Refer Table 7.2).

Level Strategy for Product 2:

A steadfast production rate of 201 units per week was upheld, requiring 7 workers each week. Three of the ten available workers were terminated during the initial week. Both ending inventory and backlog were maintained at zero, and undertime units were consistently present, totaling 29 units over five weeks. The total production cost over this period amounted to $163,560 (Refer Table 7.3).

Chase Strategy for Product 2:

Production was dynamically adjusted based on weekly demand, necessitating the hiring and firing of workers to meet demand. Undertime units persisted each week. The total production cost over five weeks amounted to $270,000 (Refer Table 7.4).

Level Strategy for Product 3:

Production was consistently set at 102 units per week, requiring 4 workers each week. Six of the ten available workers were terminated during the initial week. Two units of ending inventory were observed, and the backlog was maintained at zero. Undertime units were consistently present, totaling 90 units over five weeks. The total production cost over this period was $177,882 (Refer Table 7.5).

Chase Strategy for Product 3:

Production was dynamically adjusted based on weekly demand, leading to the hiring and firing of workers accordingly. Similar to the level strategy, undertime units were consistently present each week. The total production cost over five weeks amounted to $226,150 (Refer Table 7.6).

Level Strategy for Product 4:

A constant production rate of 88 units per week was maintained, requiring 3 workers each week. Seven of the ten available workers were terminated during the initial week. Both ending inventory and backlog were maintained at zero, and undertime units were consistently present each week, totaling 30 units over five weeks. The total production cost over this period amounted to $243,200 (Refer Table 7.7).

Chase Strategy for Product 4:

Production was dynamically adjusted based on weekly demand, leading to the hiring and firing of workers accordingly. Undertime units were consistently present each week. The total production cost over five weeks amounted to $253,140 (Refer Table 7.8).

Level Strategy for Product 5:

Production was consistently set at 44 units per week, requiring 2 workers each week. Eight of the ten available workers were terminated during the initial week. Both ending inventory and backlog were maintained at zero, and undertime units were consistently present each week, totaling 79 units over five weeks. The total production cost over this period amounted to $257,610 (Refer Table 7.9).

Chase Strategy for Product 5:

Production was dynamically adjusted based on weekly demand, leading to the necessity of dismissing workers as needed. Similar to the level strategy, undertime units persisted each week. The cumulative production cost over five weeks reached $256,840. Subsequently, a comparison of the production plans for each product will be conducted, and the associated cost implications of each strategy will be rigorously examined to yield a comprehensive understanding of the chosen production plan (Refer Table 8.0).

2.5 Master Production Schedule

The Master Production Schedule (MPS) serves as a guide for the production of individual products, specifying the quantity to be produced. As illustrated in Appendix D, the MPS is unique to each product, and the weekly production quantity is calculated accordingly. The MPS facilitates coordination between sales and production, providing a valuable means for these two functions to interact seamlessly (Table 9.1).

2.6 Material Requirement Planning

Material planning and control are greatly dependent on an MRP system. It provides data essential in building a capacity plan as well as specific instructions to execute these plans. All the information such as the bill of materials for the sub-products, and inventory status formed the basis for MRP. Safety stock and lead times were considered in calculating MRPs for each of the sub-components. The amount of material that has to be added, corresponds to the additional material rule that refers to the gross requirement and projected available balance quantity, which can not meet it. At Week 20 Sub-product 4, the exception message shows that the requirement has been rolled over into the preceding period. It is assumed we have enough on hand because our PAB was 650 (at the end of Week 20) which surpassed the gross requirement for Week 21. MRP values can be found in Appendix E.

2.7 Capacity Planning

Utilizing the MPS data for sub-products, we conducted a Capacity Plan to ascertain the required number of machines for the production plan and to calculate the overall cost for the plan illustrated in (Appendix F). Each workstation was provided with essential details such as a bill of materials, routing information, production cycle downtime, frequency of downtime, the number of machines along with their operational periods, and equipment setup time. This information enabled us to calculate the total run time needed to meet the maximum weekly capacity demand for each sub-product across workstations.

2.8 Simulation and Scheduling

When developing the simulations, the following parameters were considered:

- The command 'Wait (*Repair Time*) min', and frequency columns were added to each station's downtime clock to incorporate repair time logics and measure the time between failures.
- Used 480 minutes with no replications to satisfy the first week's production.
- Created an entity attribute to track the number of times sub-product 02 passes through Station05, which occurs twice

Initially, each sub-product is directed to the appropriate station queue based on the routings table (Table 12.1). At each station, the operation logic is applied with the aid of arrays to determine processing and setup times for the sub-product, which is then routed to its designated destination (Figure 12.2). Subsequently, the sub-product enters the respective work-in-progress (WIP) area, and each sub-product will go to its appropriate assembly station with a 'Join' command (Figure 12.3). In the assembly queue, the first-come first-served rule is followed. The assembly process involves selecting the necessary sub-products and creating the required product using the 'Join' function. The layout of our simulation model is shown in (Figure: 12.1). Despite our primary focus on the subproduct output, our simulation encompassed the entire manufacturing process, aiming to maximize machine utilization with fewer machines and less idle time. We employed various dispatching rules, such as the Vertical Forward Method, Oldest by Priority, First Come First Serve (FIFO), and Last in First Out (LIFO), to identify the most efficient model for maximizing subproduct throughput while minimizing idle time at each station. This involved evaluating the highest and lowest attributes and assigning them to processing time. Multiple experiments were conducted to find the optimal machine capacity at each location (Figure 12.4), and batch sizes at the arrivals table were adjusted based on their frequency of occurrence in the system (Figure 12.5). The use of predetermined sub-product values enabled our team to quickly deliver cost information for the sub-products (Table 12.2).

3.0 Results

Product 1

Forecasting (Assuming constant Demand)

Table 1.1

21	145
22	145
23	145
24	145
25	145

Planning: Upon assessing the aggregate plans, which yielded similar outcomes, we observed a marginal variance in the total production cost favoring the chase plan. Consequently, we opt for the level plan.

Product 2

Planning: After evaluating both aggregate plans, it is evident that the level plan surpasses the chase plan, we choose the level plan. This decision is influenced by the notably lower total cost in comparison to the chase strategy, with the firing cost contributing to increased expenses in the chase strategy.

Product 3

Planning: In the level plan, although there is a minimal ending inventory, the firing cost has substantially increased the total production cost in the chase strategy. Therefore, our preference is for the level plan in this scenario, given that the inventory cost plays a much smaller role compared to the significant impact of firing costs in the chase strategy.

Product 4

Planning: After evaluating the aggregate plans with comparable results, we noticed a slight difference in total production costs favoring the chase plan. Therefore, we have chosen the level plan. Furthermore, it's worth noting that the level plan does not involve any ending inventory.

Product 5

Planning**:** Upon comparing the two aggregate plans and considering our aim to minimize total production costs while meeting forecasted demand, we opt for the chase plan. This choice is motivated by the significantly lower total cost compared to the level strategy. Based on the MPS data, we have worked out the capacity plans and capacity bills for the 7 workstations, which reported mean overloads of about 10.32%, 12.84%, 9.109%, 17.08%, 20.31%, 15.60%, and 14.72 % each (refer to Table 8.1) and the total cost for the plan is $1698612.

Simulation Analysis

The best scheduling solution was achieved using the First-In First-Out (FIFO) method at each station, resulting in a total percentage utilization ranging from 89.57% at station 07 to 84.07%, 71.68%, and 82.46% at stations 01, 02, and 03, respectively (Figure 12.6). Initially, the Last-in First-out (LIFO) method was applied to stations 04, 05, and 06, which had the lowest utilization percentages of 48.48%, 67.49%, and 61.47%, respectively. However, this resulted in even lower values than the current percentages, rendering the method ineffective in these cases. It is important to note that although the application of LIFO to station 05 increased its percentage utilization to 68.34%, it reduced the number of sub-products produced at a given time, leading to the elimination of this method from our simulation. To achieve increased utilization in station 04, the First Highest Attribute value was set to the sub-product type, causing the sub-product to queue for assembly based on the highest value. This configuration prioritizes the departure of sub-products according to a specific attribute, which in this case is the volume of sub-products. However, it proved to be unproductive in our case, leading to the elimination of the method.

Another experiment was conducted by adjusting the capacities of each station to meet the demand of every sub-product by week 21 (Table 12.2). The experiment commenced at station 01, revealing that the initial 10 machines were insufficient. Consequently, a decision was made to procure an additional machine for that station. This extra machine facilitated the sale of a total of 62 machines from station 02 to station 07, resulting in a profit of $92,258 by week 21 (Table 12.3), after accounting for the regular costs of the sub-products for each produced at the end of week 21 (Figure 12).

4.0. Conclusion

Brown's double exponential smoothing emerged as the overall most effective forecasting method recommended for products 1, 4, and 5, showcasing its proficiency in providing low Mean Absolute Deviation (MAD) values for each product. When seasonality occurs for products 2 and 3, seasonality indexes with trend and linear regression should be taken into account for forecasting, as the lowest MADs are found when conducting those methods. These methods' capability to capture both level and pattern factors within historical data really underscores their value. Analysis of the level and chase strategies in aggregate planning revealed that the level policy proved optimal for products 1, 2, and 4, indicating the cost-effectiveness of maintaining a constant production rate for predictably stable products. Conversely, dynamic production rates were found to be more suitable for products 3 and 4, characterized by fluctuating demand. Accurate computations for Material Requirements Planning (MRP) and Master Production Scheduling (MPS) were achieved through the meticulous utilization of Bills of Materials (BOM), providing a precise framework for material acquisition and production scheduling. Capacity bills, incorporating setup times, BOM, and processing time, were developed based on input data from the MPS, establishing the groundwork for capacity requirements planning. To bolster robustness, the production sequence underwent visualization and testing in various scenarios through simulation, particularly with the aid of the Pro Model. This approach ensured adaptability to diverse variations in the production process, testing different scheduling methods with different machine capacities at each station, resulting in a decrease of 62 machines, leaving 34 total machines at each station to complete production.

4.1. Recommendation

Consistently employ Brown's double exponential smoothing for ongoing and future forecasting efforts to enhance the accuracy of demand predictions across all items while carefully analyzing for seasonality in each demand. Capitalize on the stable demand for products 1, 2, and 4 by implementing a level production policy, streamlining production processes, and minimizing adjustment costs. For items 3 and 5, adopt a chase production policy to adjust production quantities in response to demand changes, preventing excessive inventory or shortages. Ensure prompt reflection of any alterations in demand forecasts or actual orders through regular updates of the Master Production Schedule (MPS) and Material Requirements Planning (MRP) to maintain synchronization. Continuously compare actual setup times and processing capacities with the capacity bills to identify improvement opportunities and ensure alignment with capacity planning. Integrate simulation modeling into the planning process for alternative scenarios, preparing contingency plans for increased demand or disruptions in the supply chain. Conduct training sessions for forecasting and production-planning personnel to ensure proficiency in relevant techniques and software, including Brown's double exponential smoothing and ProModel simulation software, respectively. Lastly, regularly monitor and update these recommendations as additional information becomes available and market conditions evolve, ensuring the sustained effectiveness and productivity of the manufacturing system.

References

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Appendix A

Tables and Figures for Product 1

Figure 1.1 *Demand Plot for Product 1*

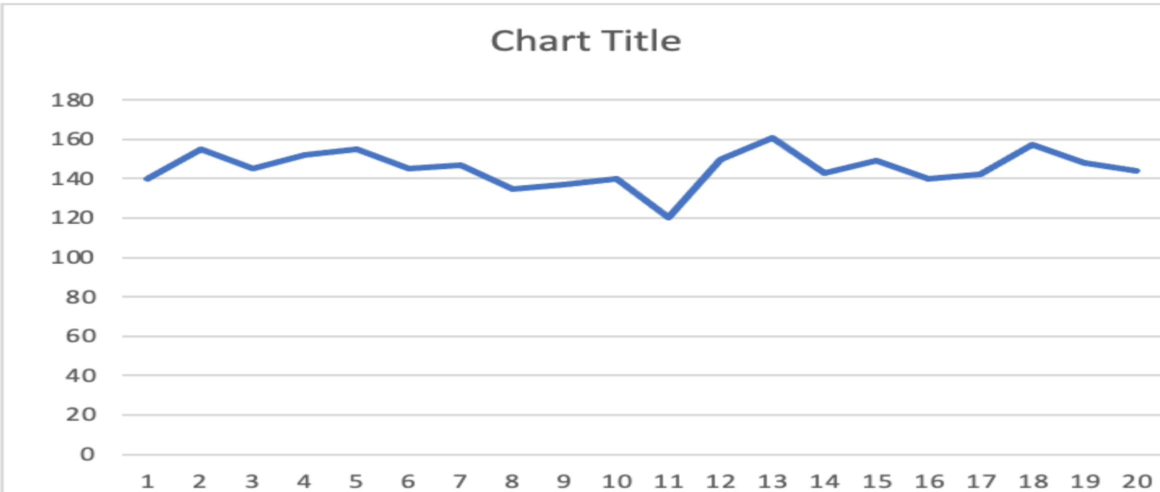

Table 1.1 *Forecast for Product 1: 25-Week Projection with Exponential Smoothing*

	Product 1	Exponential
1	140	140
2	155	140
3	145	141.5
4	152	141.85
5	155	142.865
6	145	144.0785
7	147	144.17065
8	135	144.453585
9	137	143.508227
10	140	142.857404
11	120	142.571663
12	150	140.314497
13	161	141.283047
14	143	143.254743
15	149	143.229268
16	140	143.806342
17	142	143.425707
18	157	143.283137
19	148	144.654823
20	144	144.989341
21	145	144.890407
22	145	144.890407
23	145	144.890407
24	145	144.890407
25	145	144.890407
	MAD	8.12830232

Tables and Figures for Product 2

Figure 2.1 *Demand Plot for Product 2*

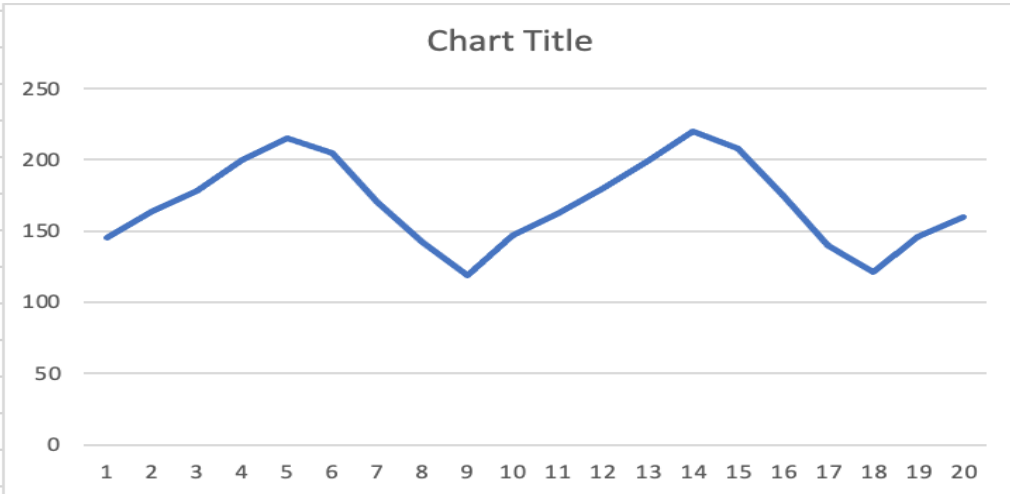

Table 2.1 *Seasonal Forecast Calculations for Product 2: 25-Week Projection*

Week	Season-1	Season-2	Season-3	
1	145.00	147.00	146.00	
2	164.00	162.00	160.00	
3	178.00	180.00	Week21	
4	200.00	199.00	Week22	
5	215.00	220.00	Week23	
6	205.00	208.00	Week24	
7	170.00	175.00	Week25	
8	142.00	140.00		
9	119.00	121.00		
Total	1538.00	1552.00	**1600.00**	**Assumed**
Average	170.89	172.44	153.00	

Table 2.2
Forecasting Product 2 and MAD Calculations

Week	Season-1	Season-2	Season-3	Seasonal Index	Normalize	Season-3 Forecast
1	0.85	0.85	0.95	0.89	0.87856047	156.19
2	0.96	0.94	1.05	0.98	0.97440768	173.23
3	1.04	1.04	Week21	1.04	1.03504785	184.01
4	1.17	1.15	Week22	1.16	1.15362915	205.09
5	1.26	1.28	Week23	1.27	1.25763621	223.58
6	1.20	1.21	Week24	1.20	1.19405451	212.28
7	0.99	1.01	Week25	1.00	0.99742207	177.32
8	0.83	0.81		0.82	0.81536386	144.95
9	0.70	0.70		0.70	0.69387819	123.36
				9.07	9	1,600.00

Period **t**	**Actual Demand**	**Forecast**	**Error**
1	145.00	151.25	6.25
2	164.00	167.75	3.75
3	178.00	178.19	0.19
4	200.00	198.60	1.40
5	215.00	216.51	1.51
6	205.00	205.56	0.56
7	170.00	171.71	1.71
8	142.00	140.37	1.63
9	119.00	119.45	0.45
10	147.00	152.62	5.62
11	162.00	169.28	7.28
12	180.00	179.81	0.19
13	199.00	200.41	1.41
14	220.00	218.48	1.52
15	208.00	207.43	0.57
16	175.00	173.27	1.73
17	140.00	141.65	1.65
18	121.00	120.54	0.46
19	146.00	156.19	10.19
20	160.00	173.23	13.23
21		184.01	
22		205.09	
23		223.58	
24		212.28	
25		177.32	
		MAD	**3.06**

Tables and Figures for Product 3

Figure 3.1 *Demand Plot for Product 3*

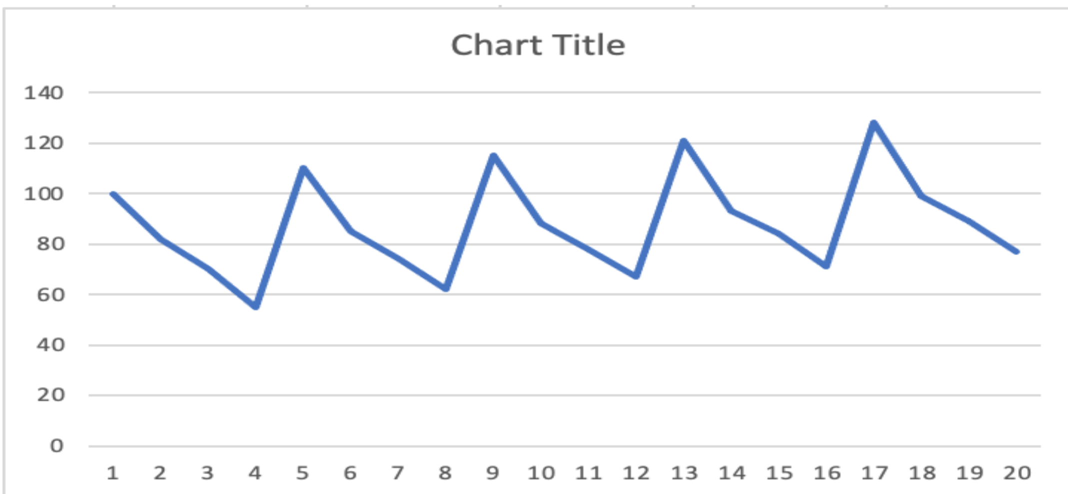

Figure 3.2 *Scatter Chart with Linear Line with Equation Plot for Product 3*

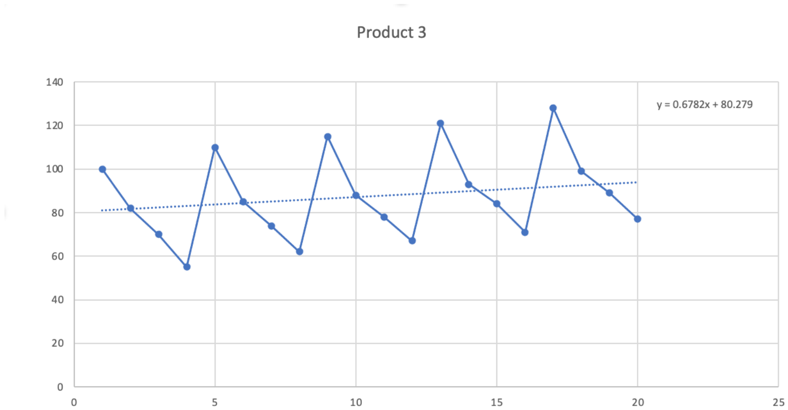

Table 3.1 *Product 3 Forecast: 25-Week Projection Using Exponential Smoothing with Trend*

Week	Seasonality Index
Week 1	1.31
Week 2	1.02
Week 3	0.90
Week 4	0.76

Intercept	80.2789474
Slope	0.67819549

Period t	Seasons	Week	Actual Demand	Linear Trend Forecast	Seasonal Forecast with Trend	Error
1	Season 1	Week 1	100.00	80.96	106.34	
2		Week 2	82.00	81.64	83.50	
3		Week 3	70.00	82.31	74.40	
4		Week 4	55.00	82.99	63.05	
5	Season 2	Week 1	110.00	83.67	109.90	
6		Week 2	85.00	84.35	86.28	
7		Week 3	74.00	85.03	76.85	
8		Week 4	62.00	85.70	65.11	
9	Season 3	Week 1	115.00	86.38	113.46	
10		Week 2	88.00	87.06	89.05	
11		Week 3	78.00	87.74	79.31	1.31
12		Week 4	67.00	88.42	67.17	0.17
13	Season 4	Week 1	121.00	89.10	117.03	3.97
14		Week 2	93.00	89.77	91.83	1.17
15		Week 3	84.00	90.45	81.76	2.24
16		Week 4	71.00	91.13	69.23	1.77
17	Season 5	Week 1	128.00	91.81	120.59	7.41
18		Week 2	99.00	92.49	94.60	4.40
19		Week 3	89.00	93.16	84.21	4.79
20		Week 4	77.00	93.84	71.29	5.71
21	Season 6	Week 1		94.52	124.15	
22		Week 2		95.20	97.38	
23		Week 3		95.88	86.66	
24		Week 4		96.56	73.36	
25		Week 1		97.23	127.72	
					MAD	3.29

Tables and Figures for Product 4

Figure 4.1 *Demand Plot for Product 4*

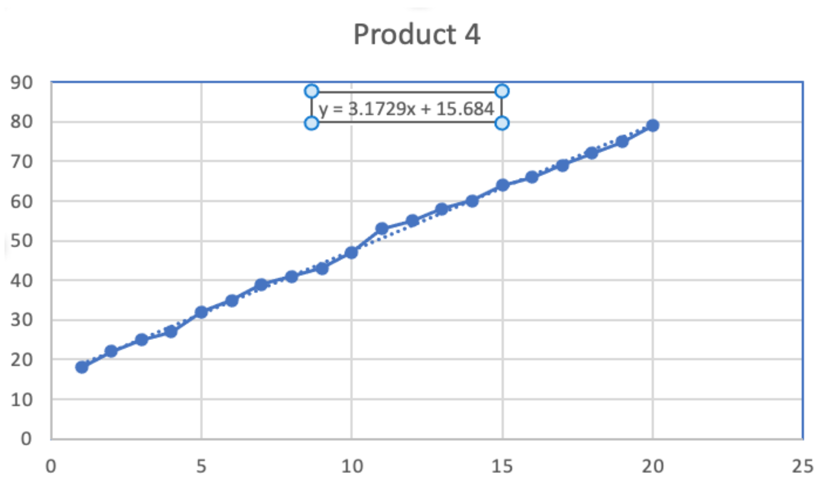

Table 4.1 *Forecast for Product 4: 25-Week Projection with Exponential Smoothing with No Trend*

	Base :-	F(t) =	15.684		
	Trend :-	T(t) =	3.1729		
		α =	0.2		
		β =	0.4		

Period	*Actual Demand*	*F(t)*	*T(t)*	*FTT*	*ERROR*
1	18	15.684	3.173		
2	22	18.686	3.104		
3	25	21.832	3.121		
4	27	24.962	3.125		
5	32	27.870	3.038		
6	35	31.126	3.125		
7	39	34.401	3.185		
8	41	37.869	3.298		
9	43	41.134	3.285		
10	47	44.135	3.171	47.306	
11	53	47.245	3.147	50.392	2.608
12	55	50.914	3.355	54.269	0.731
13	58	54.415	3.414	57.829	0.171
14	60	57.863	3.428	61.291	1.291
15	64	61.033	3.324	64.357	0.357
16	66	64.286	3.296	67.582	1.582
17	69	67.265	3.169	70.434	1.434
18	72	70.148	3.054	73.202	1.202
19	75	72.962	2.958	75.920	0.920
20	79	75.736	2.885	78.621	0.379
21		78.697	2.915	**81.612**	
22				**84.527**	
23				**87.442**	
24				**90.357**	
25				**93.272**	
				MAD=	1.07

Tables and Figures for Product 5

Figure 5.1 *Demand Plot for Product 5*

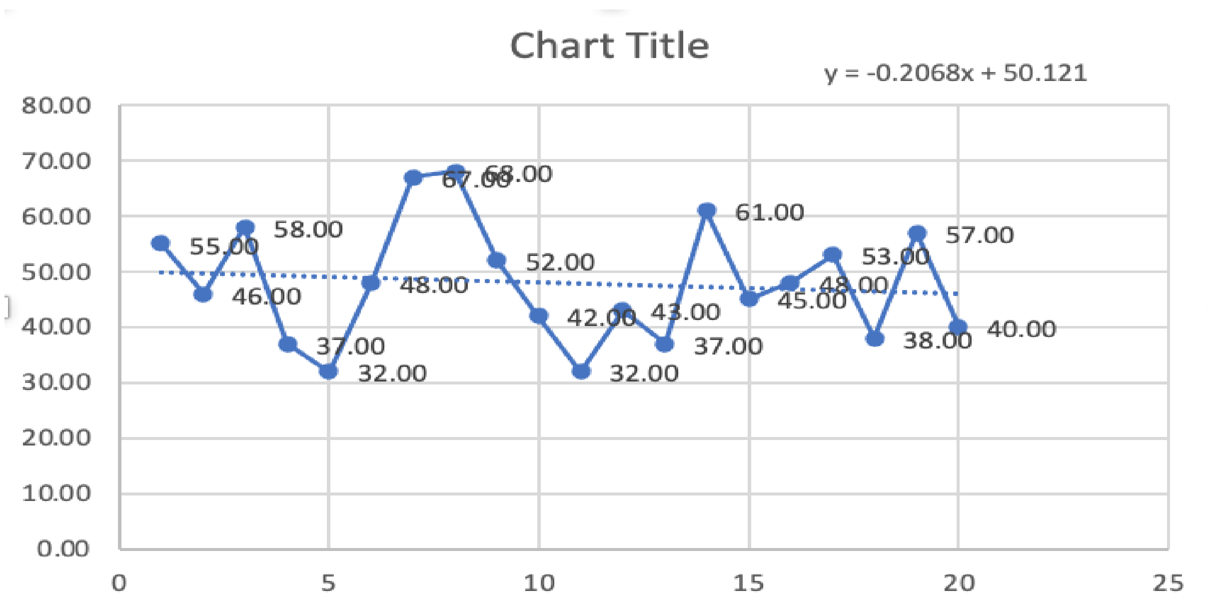

Table 5.1 *Forecast for Product 4: 25-Week Projection with Exponential Smoothing*

	α =	0.6		
Period	***Actual Demand***	***Forecast***	***Error***	
1	55.00	55		
2	46.00	55.00		
3	58.00	49.60		
4	37.00	54.64		
5	32.00	44.06		
6	48.00	36.82		
7	67.00	43.53		
8	68.00	57.61		
9	52.00	63.84		
10	42.00	56.74		
11	32.00	47.90	15.90	
12	43.00	38.36	4.64	
13	37.00	41.14	4.14	
14	61.00	38.66	22.34	
15	45.00	52.06	7.06	
16	48.00	47.83	0.17	
17	53.00	47.93	5.07	
18	38.00	50.97	12.97	
19	57.00	43.19	13.81	
20	40.00	51.48	11.48	
21		51.00		
22		38.00		
23		41.00		
24		39.00		
25		52.00		
		MAD=	9.76	

Appendix B

Brown’s Double Exponential Smoothing

Table 6.1 - Product 1

HISTORY HORIZON	Product 1	At	A"t	at	bt	Forecast	Error	
1	140	140	140	140	11			
2	155	141.5	140.15	142.85	0.15	151	4	
3	145	141.85	140.32	143.38	0.17	143	2	
4	152	142.865	140.5745	145.1555	0.2545	143.55	8.45	
5	155	144.0785	140.9249	147.2321	0.3504	145.41	9.59	
6	145	144.17065	141.249475	147.091825	0.324575	147.5825	2.5825	
7	147	144.453585	141.569886	147.337284	0.320411	147.4164	0.4164	
8	135	143.5082265	141.7637201	145.252733	0.19383405	147.657695	12.657695	
9	137	142.8574039	141.8730884	143.8417193	0.10936838	145.446567	8.446567	
10	140	142.5716635	141.9429459	143.200381	0.0698575035	143.9510877	3.95108765	
11	120	140.3144971	141.7801011	138.8488932	-0.1628448815	143.2702385	23.2702385	
12	150	141.2830474	141.7303957	140.8356991	-0.0497053645	138.6860483	11.3139517	
13	161	143.2547427	141.8828304	144.6266549	0.1524346979	140.7859938	20.21400624	
14	143	143.2292684	142.0174742	144.4410626	0.1346438014	144.7790896	1.779089645	
15	149	143.8063416	142.1963609	145.4163222	0.1788867373	144.5757064	4.424293587	
16	140	143.4257074	142.3192956	144.5321192	0.122934648	145.5952089	5.595208932	
17	142	143.2831367	142.4156797	144.1505936	0.09638410912	144.6550539	2.655053883	
18	157	144.654823	142.639594	146.670052	0.2239143316	144.2469778	12.75302225	
19	148	144.9893407	142.8745687	147.1041127	0.2349746685	146.8939663	1.106033687	**MAD**
20	144	144.8904066	143.0761525	146.7046608	0.2015837946	147.3390874	3.339087382	**8.706198606**
21						147.1078284		
22						147.3094122		
23						147.510996		
24						147.7125798		
25						147.9141635		

Table 6.2 - Product 2

History Horizon	Product 2	At	A"t	at	bt	Forecast	Error	
1	145	145	145	145	20.5			
2	164	162.1	160.39	163.81	15.39	165.5	1.5	
3	178	176.41	174.808	178.012	14.418	179.2	1.2	
4	200	197.641	195.3577	199.9243	20.5497	192.43	7.57	
5	215	213.2641	211.47346	215.05474	16.11576	220.474	5.474	
6	205	205.82641	206.391115	205.261705	-5.082345	231.1705	26.1705	
7	170	173.582641	176.8634884	170.3017936	-29.5276266	200.17936	30.17936	
8	142	145.1582641	148.3287865	141.9877417	-28.53470187	140.774167	1.225833	
9	119	121.6158264	124.2871224	118.9445304	-24.04166411	113.4530398	5.5469602	
10	147	144.4615826	142.4441366	146.4790287	18.1570142	94.90286629	52.09713371	
11	162	160.2461583	158.4659561	162.0263604	16.02181948	164.6360429	2.63604286	
12	180	178.0246158	176.0687499	179.9804818	17.60279375	178.0481799	1.951820091	
13	199	196.9024616	194.8190904	198.9858328	18.75034056	197.5832756	1.416724447	
14	220	217.6902462	215.4031306	219.9773617	20.58404017	217.7361733	2.263826688	
15	208	208.9690246	209.6124352	208.325614	-5.790695371	240.5614019	32.56140191	
16	175	178.3969025	181.5184557	175.2753492	-28.09397948	202.5349186	27.53491865	
17	140	143.8396902	147.6075668	140.0718137	-33.91088894	147.1813697	7.181369711	
18	121	123.283969	125.7163288	120.8516092	-21.89123799	106.1609248	14.83907524	
19	146	143.7283969	141.9271901	145.5296037	16.21086129	98.96037125	47.03962875	**MAD**
20	160	158.3728397	156.7282747	160.0174047	14.80108464	161.740465	1.740465003	13.91652733
21						189.6195739		
22						204.4206586		
23						219.2217432		
24						234.0228278		
25						248.8239125		

Table 6.3 - Product 3

HISTORY HORIZON	Product 3	At	A"t	at	bt	Forecast	Error	
1	100	100	100	100	0			
2	82	98.2	99.82	96.58	-0.18	100	18	
3	70	95.38	99.376	91.384	-0.444	96.4	26.4	
4	55	91.342	98.5726	84.1114	-0.8034	90.94	35.94	
5	110	93.2078	98.03612	88.37948	-0.53648	83.308	26.692	
6	85	92.38702	97.47121	87.30283	-0.56491	87.843	2.843	
7	74	90.548318	96.7789208	84.3177152	-0.6922892	86.73792	12.73792	
8	62	87.6934862	95.87037734	79.51659506	-0.90854346	83.625426	21.625426	
9	115	90.42413758	95.32575336	85.5225218	-0.544623976	78.6080516	36.3919484	
10	88	90.18172382	94.81135041	85.55209723	-0.5144029542	84.97789782	3.02210218	
11	78	88.96355144	94.22657051	83.70053237	-0.584779897	85.03769428	7.03769428	
12	67	86.7671963	93.48063309	80.0537595	-0.7459374217	83.11575247	16.11575247	
13	121	90.19047667	93.15161745	87.22933588	-0.3290156425	79.30782208	41.69217792	
14	93	90.471429	92.8835986	88.0592594	-0.2680188449	86.90032024	6.099679759	
15	84	89.8242861	92.57766735	87.07090485	-0.3059312504	87.79124055	3.791240551	
16	71	87.94185749	92.11408637	83.76962861	-0.4635809864	86.7649736	15.7649736	
17	128	91.94767174	92.0974449	91.79789858	-0.0166414626	83.30604763	44.69395237	
18	99	92.65290457	92.15299087	93.15281826	0.05554596623	91.78125711	7.218742886	
19	89	92.28761411	92.16645319	92.40877503	0.01346232394	93.20836423	4.208364229	**MAD**
20	77	90.7588527	92.02569314	89.49201225	-0.1407600496	92.42223735	15.42223735	16.20448154
21						89.21049215		
22						89.0697321		
23						88.92897205		
24						88.78821201		
25						88.64745196		

Table 6.4 - Product 4

History Horizon	Product 4	At	A"t	at	bt	Forecast	Error	
1	18	18	18	18	3			
2	22	20	19	21	1	21	1	
3	25	22.5	20.75	24.25	1.75	22	3	
4	27	24.75	22.75	26.75	2	26	1	
5	32	28.375	25.5625	31.1875	2.8125	28.75	3.25	
6	35	31.6875	28.625	34.75	3.0625	34	1	
7	39	35.34375	31.984375	38.703125	3.359375	37.8125	1.1875	
8	41	38.171875	35.078125	41.265625	3.09375	42.0625	1.0625	
9	43	40.5859375	37.83203125	43.33984375	2.75390625	44.359375	1.359375	
10	47	43.79296875	40.8125	46.7734375	2.98046875	46.09375	0.90625	
11	53	48.39648438	44.60449219	52.18847656	3.791992188	49.75390625	3.24609375	
12	55	51.69824219	48.15136719	55.24511719	3.546875	55.98046875	0.98046875	
13	58	54.84912109	51.50024414	58.19799805	3.348876953	58.79199219	0.7919921875	
14	60	57.42456055	54.46240234	60.38671875	2.962158203	61.546875	1.546875	
15	64	60.71228027	57.58734131	63.83721924	3.124938965	63.34887695	0.6511230469	
16	66	63.35614014	60.47174072	66.24053955	2.884399414	66.9621582	0.9621582031	
17	69	66.17807007	63.3249054	69.03123474	2.853164673	69.12493896	0.1249389648	
18	72	69.08903503	66.20697021	71.97109985	2.882064819	71.88439941	0.1156005859	
19	75	72.04451752	69.12574387	74.96329117	2.918773651	74.85316467	0.1468353271	MAD
20	79	75.52225876	72.32400131	78.7205162	3.198257446	77.88206482	1.117935181	0.9684020996
21						85.1170311		
22						88.31528854		
23						91.51354599		
24						94.71180344		
25						97.91006088		

Table 6.5 - Product 5

History Horizon	Product 5	At	A"t	at	bt	Forecast	Error	
1	55	55	55	55	-15			
2	46	54.1	54.91	53.29	-0.09	40	6	
3	58	54.49	54.868	54.112	-0.042	53.2	4.8	
4	37	52.741	54.6553	50.8267	-0.2127	54.07	17.07	
5	32	50.6669	54.25646	47.07734	-0.39884	50.614	18.614	
6	48	50.40021	53.870835	46.929585	-0.385625	46.6785	1.3215	
7	67	52.060189	53.6897704	50.4306076	-0.1810646	46.54396	20.45604	
8	68	53.6541701	53.68621037	53.62212983	-0.00356003	50.249543	17.750457	
9	52	53.48875309	53.66646464	53.31104154	-0.019745728	53.6185698	1.6185698	
10	42	52.33987778	53.53380596	51.14594961	-0.1326586861	53.29129581	11.29129581	
11	32	50.30589	53.21101436	47.40076565	-0.3227915953	51.01329092	19.01329092	
12	43	49.575301	52.84744302	46.30315898	-0.3635713358	47.07797405	4.07797405	
13	37	48.3177709	52.39447581	44.24106599	-0.4529672122	45.93958764	8.939587645	
14	61	49.58599381	52.11362761	47.05836001	-0.2808482	43.78809878	17.21190122	
15	45	49.12739443	51.81500429	46.43978457	-0.2986233182	46.77751181	1.777511812	
16	48	49.01465499	51.53496936	46.49434061	-0.2800349307	46.14116125	1.858838751	
17	53	49.41318949	51.32279138	47.5035876	-0.2121779875	46.21430568	6.785694319	
18	38	48.27187054	51.01769929	45.52604179	-0.3050920836	47.29140961	9.291409614	
19	57	49.14468349	50.83039771	47.45896926	-0.1873015807	45.2209497	11.7790503	**MAD**
20	40	48.23021514	50.57037945	45.89005082	-0.2600182574	47.27166768	7.27166768	8.800692631
21						45.37001431		
22						45.10999605		
23						44.84997779		
24						44.58995953		
25						44.32994128		

Appendix C

Aggregate Planning

Product 1

Table 7.1 *Aggregate Plan for Product 1 using Level Strategy*

Week	21	22	23	24	25	Total	Production Cost($)
Beginning Inventory	0	0	0	0	0	0	
Capacity	150	150	150	150	150	750	
Production	145	145	145	145	145	725	72500
Demand	145	145	145	145	145	725	
Workers Needed	5	5	5	5	5	25	
Workers Available	10	5	5	5	5		
Workers Hired	0	0	0	0	0	0	
Workers Fired	5	0	0	0	0	5	125000
Undertime units	5	5	5	5	5	25	4000
End Inventory	0	0	0	0	0	0	0
Backlog	0	0	0	0	0	0	0
Average Inventory	0	0	0	0	0	0	
							201500

Table 7.2 *Aggregate Plan for Product 1 using Chase Strategy*

Week	21	22	23	24	25	Total	Production Cost($)
Beginning Inventory	0	0	0	0	0	0	
Capacity	150	150	150	150	150	750	75000
Production	145	145	145	145	145	725	
Demand	145	145	145	145	145	725	
Workers Needed	5	5	5	5	5	25	
Workers Available	10					10	
Workers Hired	0	0	0	0	0	0	
Workers Fired	5	0	0	0	0	5	125000
Undertime units	5	5	5	5	5	25	4000
End Inventory	0	0	0	0	0	0	
Backlog	0	0	0	0	0	0	
Average Inventory	0	0	0	0	0	0	
							204000

Product 2

Table 7.3 *Aggregate Plan for Product 2 using Level Strategy*

Week	21	22	23	24	25	Total	Production Cost($)
Beginning Inventory	0	17	12	0	0	29	
Capacity	210	210	210	210	210	1050	
Production	201	201	201	201	201	1005	80400
Demand	184	206	224	213	178	1005	
Workers Needed	7	7	7	7	7	35	
Workers Available	10					10	
Workers Hired	0	0	0	0	0	0	
Workers Fired	3	0	0	0	0	3	75000
Undertime units	9	9	9	9	9	45	7200
End Inventory	17	12	0	0	0	29	348
Backlog	0	0	11	23	0	34	612
Average Inventory	9	15	6	0	0	29	
							163560

Table 7.4 *Aggregate Plan for Product 2 using Chase Strategy*

Week	21	22	23	24	25	Total	Production Cost($)
Beginning Inventory	0	0	0	0	0	0	
Capacity	210	210	240	240	180	1080	108000
Production	184	206	224	213	178	1005	
Demand	184	206	224	213	178	1005	
Workers Needed	7	7	8	8	6	36	
Workers Available	10					10	
Workers Hired	0	0	1	0	0	1	25000
Workers Fired	3	0	0	0	2	5	125000
Undertime units	26	4	16	27	2	75	12000
End Inventory	0	0	0	0	0	0	
Backlog	0	0	0	0	0	0	
Average Inventory	0	0	0	0	0	0	
							270000

Product 3

Table 7.5 *Aggregate Plan for Product 3 using Level Strategy*

Week	21	22	23	24	25	Total	Production Cost($)
Beginning Inventory	0	0	0	0	28	28	
Capacity	120	120	120	120	120	600	
Production	102	102	102	102	102	510	12750
Demand	124	97	87	74	128	510	
Workers Needed	4	4	4	4	4	20	
Workers Available	10						
Workers Hired	0	0	0	0	0	0	
Workers Fired	6	0	0	0	0	6	150000
Undertime units	18	18	18	18	18	90	14400
End Inventory	0	0	11	28	2	41	471.5
Backlog	22	4	0	0	0	26	260
Average Inventory	0	0	0	0	9	9	
							177881.5

Table 7.6 *Aggregate Plan for Product 3 using Chase Strategy*

Week	21	22	23	24	25	Total	Production Cost($)
Beginning Inventory	0	0	0	0	0	0	
Capacity	150	120	90	90	150	600	
Production	124	97	87	74	128	510	12750
Demand	124	97	87	74	128	510	
Workers Needed	5	4	3	3	5	20	
Workers Available	10	5	4	3	3	25	
Workers Hired	0	0	0	0	2	2	24000
Workers Fired	5	1	1	0	0	7	175000
Undertime units	26	23	3	16	22	90	14400
End Inventory	0	0	0	0	0	0	
Backlog	0	0	0	0	0	0	
Average Inventory	0	0	0	0	0	0	
							226150

Product 4

Table 7.7 *Aggregate Plan for Product 4 using Level Strategy*

Week	21	22	23	24	25	Total	Production Cost($)
Beginning Inventory	0	6	9	9	6	30	
Capacity	90	90	90	90	90	450	
Production	88	88	88	88	88	440	66000
Demand	82	85	88	91	94	440	
Workers Needed	3	3	3	3	3	15	
Workers Available	10						
Workers Hired	0	0	0	0	0	0	
Workers Fired	7	0	0	0	0	7	175000
Undertime units	2	2	2	2	2	10	1600
End Inventory	6	9	9	6	0	30	600
Backlog	0	0	0	0	0	0	0
Average Inventory	3	8	9	8	3	30	
							243200

Table 7.8 *Aggregate Plan for Product 4 using Chase Strategy*

Week	21	22	23	24	25	Total	Production Cost($)
Beginning Inventory	0	0	0	0	0	0	
Capacity	90	90	90	120	120	510	
Production	82	85	88	91	94	440	66000
Demand	82	85	88	91	94	440	
Workers Needed	3	3	3	4	4	17	
Workers Available	10						
Workers Hired	0	0	0	1	0	1	12000
Workers Fired	7	0	0	0	0	7	175000
Undertime units	8	5	2	29	26	70	140
End Inventory	0	0	0	0	0	0	
Backlog	0	0	0	0	0	0	
Average Inventory	0	0	0	0	0	0	
							253140

Product 5

Table 7.9 *Aggregate Plan for Product 5 using Level Strategy*

Week	21	22	23	24	25	Total	Production Cost($)
Beginning Inventory	0	0	0	2	8	10	
Capacity	60	60	60	60	60	300	
Production	44	44	44	44	44	221	44200
Demand	51	38	41	39	52	221	
Workers Needed	2	2	2	2	2	10	
Workers Available	10						
Workers Hired	0	0	0	0	0	0	
Workers Fired	8	0	0	0	0	8	200000
Undertime units	16	16	16	16	16	79	12640
End Inventory	0	0	2	8	0	10	185
Backlog	7	1	0	0	0	8	585
Average Inventory	0	0	1	5	4	10	
							257610

Table 7.10 *Aggregate Plan for Product 5 using ChaseStrategy*

Week	21	22	23	24	25	Total	Production Cost($)
Beginning Inventory	0	0	0	0	0	0	
Capacity	60	60	60	60	60	300	
Production	51	38	41	39	52	221	44200
Demand	51	38	41	39	52	221	
Workers Needed	2	2	2	2	2	10	
Workers Available	10	2	2	2	2	18	
Workers Hired	0	0	0	0	0	0	
Workers Fired	8	0	0	0	0	8	200000
Undertime units	9	22	19	21	8	79	12640
End Inventory	0	0	0	0	0	0	
Backlog	0	0	0	0	0	0	
Average Inventory	0	0	0	0	0	0	
							256840

Appendix D

Master Production Schedule (MPS)

Table 9.1

Master Production Schedule (MPS)

Master Production Schedule						
Subproduct 1	**Week**		Q = 1000	SS = 100		
	21	22	23	24	25	
Forecast	1275	1185	1203	1192	1340	
Orders	1000	1000	2000	1000	1000	
PAB 450	175	990	990	798	458	
ATP	450	1000	0	0	0	
MPS	1000	2000	2000	1000	1000	
			Q = 200	SS = 0		
Subproduct 2	**Week**					
	21	22	23	24	25	
Forecast	133	123	128	129	145	
Orders	0	200	200	0	200	
PAB 150	17	17	17	88	88	
ATP	150	0	0	200	0	
MPS	0	200	200	200	200	
			Q = 2 period fixed		SS =	25
Subproduct 3	**Week**					
	21	22	23	24	25	
Forecast	492	509	533	497	482	
Orders	751	0	994	0	410	
PAB 200	450	-59	424	-73	-145	
ATP			483		0	
MPS	1001		1477		410	
			Q = Lot for lot	SS =	50	
Subproduct 4	**Week**					
	21	22	23	24	25	
Forecast	1459	1442	1472	1375	1458	
Orders	1508	1442	1472	1375	1458	
PAB 650	650	650	650	650	650	
ATP	650	0	0	0	0	
MPS	1508	1442	1472	1375	1458	

Appendix E

Material Requirement Planning (MRP)

Table 10.1- Product 1

PRODUCT 1						
Product 1	**21**	**22**	**23**	**24**	**25**	
	145	145	145	145	145	
Sub-product 4	**Past due**					
		21	**22**	**23**	**24**	**25**
Gross Requirements		145	145	145	145	145
Scheduled receipt						
PAB / 650		505	360	215	70	50
Net Requirement						125
Planned order receipt						125
planned order release					125	
Q= L4L; LT =1; SS =50						
Sub-product 1	**Past Due**					
		21	**22**	**23**	**24**	**25**
Gross Requirements		435	435	435	435	435
Scheduled receipt						
PAB / 450		1015	580	145	710	275
Net Requirement		85	435	432	429	435
Planned order receipt		1000			1000	
planned order release	1000			1000		
Q= 1000; LT =1; SS =100						

Table 10.2 - Product 2

PRODUCT 2

Product 2	21	22	23	24	25
	184	205	224	212	177

Sub-product 3	Past due					
		21	22	23	24	25
Gross Requirements		184	205	224	212	177
Scheduled receipt						
PAB / 650		466	261	37	50	50
Net Requirement				13	212	177
Planned order receipt				13	212	177
planned order release				212	177	
Q= L4L; LT =1; SS =50						

Sub-product 4	Past due					
		21	22	23	24	25
Gross Requirements		368	410	448	424	354
Scheduled receipt						
PAB / 200		25	25	25	25	25
Net Requirement		193	410	448	424	354
Planned order receipt		603		872		312
planned order release	603		872		312	
Q= Fixed 2 periods; LT =1; SS = 25						

Sub-product 4	Past due					
		21	22	23	24	25
Gross Requirements		2412	3488		1248	
Scheduled receipt						
PAB / 650		50	50	50	50	
Net Requirement		1812	3488		1248	
Planned order receipt		1812	3488		1248	
planned order release	1780	3488		1248		
Q= L4L; LT =1; SS =50						

Table 10.3 - Product 3

Product 3						
Product 3	**21**	**22**	**23**	**24**	**25**	
	124	97	87	73	128	

Sub-product 1	**Past due**					
		21	**22**	**23**	**24**	**25**
Gross Requirements		124	97	87	73	128
Scheduled receipt						
PAB / 450		326	229	142	1069	941
Net Requirement					73	128
Planned order receipt					1000	
planned order release				1000		
Q= 1000; LT =1; SS =100						

Sub-product 3	**Past due**					
		21	**22**	**23**	**24**	**25**
Gross Requirements		124	97	87	73	128
Scheduled receipt						
PAB / 200		76	112	25	153	25
Net Requirement			46	87	73	128
Planned order receipt			133		201	
planned order release		133		201		
Q= Fixed 2 periods; LT =1; SS =25						

Sub-product 4	**Past due**					
		21	**22**	**23**	**24**	**25**
Gross Requirements		532		804		
Scheduled receipt						
PAB / 650		50		50		
Net Requirement		168		280		
Planned order receipt		168		280		
planned order release	168		280			
Q= L4L; LT =1; SS =50						

Table 10.4 - Product 4

Product 4						
Product 4		**21**	**22**	**23**	**24**	**25**
		82	85	87	90	93
Sub-product 4	**Past due**					
		21	**22**	**23**	**24**	**25**
Gross Requirements		82	85	87	90	93
Scheduled receipt						
PAB / 650		568	565	563	560	557
Net Requirement						
Planned order receipt						
planned order release						
Q= L4L; LT =1; SS =50						
Sub-product 2	**Past due**					
		21	**22**	**23**	**24**	**25**
Gross Requirements		82	85	87	90	93
Scheduled receipt						
PAB / 150		68	183	96	6	113
Net Requirement			17			93
Planned order receipt			200			200
planned order release			200			200
Q= 200; LT =0; SS =0						
Sub-product 1	**Past due**					
		21	**22**	**23**	**24**	**25**
Gross Requirements			1000			1000
Scheduled receipt						
PAB / 450		450	450	450	450	450
Net Requirement			550			550
Planned order receipt			1000			
planned order release		1000			1000	
Q= 1000; LT =1; SS =100						

Table 10.5 - Product 5

Product 5						
Product 5		**21**	**22**	**23**	**24**	**25**
		51	38	41	39	52
Sub-product 1	**Past due**					
		21	**22**	**23**	**24**	**25**
Gross Requirements		51	38	41	39	52
Scheduled receipt						
PAB / 450		399	361	320	281	229
Net Requirement						
Planned order receipt						
planned order release						
Q= 1000; LT =1; SS =100						
Sub-product 2	**Past due**					
		21	**22**	**23**	**24**	**25**
Gross Requirements		51	38	41	39	52
Scheduled receipt						
PAB / 150		99	61	20	181	129
Net Requirement					19	40
Planned order receipt					200	
planned order release					200	
Q= 200; LT =0; SS =0						
Sub-product 1	**Past due**					
		21	**22**	**23**	**24**	**25**
Gross Requirements					1000	
Scheduled receipt						
PAB / 450		450	450	450	450	
Net Requirement					550	
Planned order receipt					1000	
planned order release						
Q= 1000; LT =1; SS =100						

Appendix F

Capacity planning

Table 11.1 - Aggregate Capacity Bill

	WEEK 21	WEEK 22	WEEK 23	WEEK 24	WEEK 25	Total	PERCENTAGE OF WS
WS 1	71052	37517	24270	25800	4270	162909	10.327043
WS 2	75847	52833	33283	35559	5035	202557	12.84038849
WS 3	59454	39359	17960	22970	3960	143703	9.109546187
WS 4	113650	53394	51582	49126	1710	269462	17.08159561
WS 5	125534	75606	56886	59038	3390	320454	20.31405408
WS 6	96145	51865	49600	46080	2510	246200	15.60698295
WS 7	98937	47172	42605	42955	545	232214	14.72038968
					TOTAL	1577499	100

Table 11.2 - Number of Machines used per week

NUMBER OF MACHINES USED ON EACH WORKSTATION

	Week				
Station	21	22	23	24	25
1	34	18	12	12	2
2	36	25	16	17	3
3	30	20	9	12	2
4	53	25	24	23	1
5	60	37	28	29	2
6	43	24	23	21	2
7	47	22	20	20	1

Appendix G

Simulation & Scheduling

Table 12.1

Table 4. Routings

Sub-Product Type	Route
1	1, 2, 3, 4, 5, 6, 7
2	1, 5, 4, 3, 2, 6, 5
3	7, 3, 5, 2, 1
4	4, 2, 7, 5, 6

Table 12.2

Product D.	Sub01	Sub02	Sub03	Sub04
145	435			140
184			368	920
124	124		124	496
82	410	82		82
51	306	51		
TOTAL	1275	133	492	1638

Table 12.3

Cost Information of Sub-Products

	Machine Bought	Machine Sold	Current Machines				
Sta01	1	0	11			Buy Machine Cost	4500
Sta02		13	7			Resale Machine Cost	2250
Sta03		8	2				
Sta04		10	5				
Sta05		11	4				
Sta06		17	3				
Sta07		3	2				
TOTAL	1	62					
	Sub01	Sub02	Sub03	Sub03		Sub01	7
Reg. Cost	1275	133	492	1639		Sub02	25
TOTAL	8925	3325	10824	19668		Sub03	22
						Sub04	12
Cost	92258						

Figure 12.1

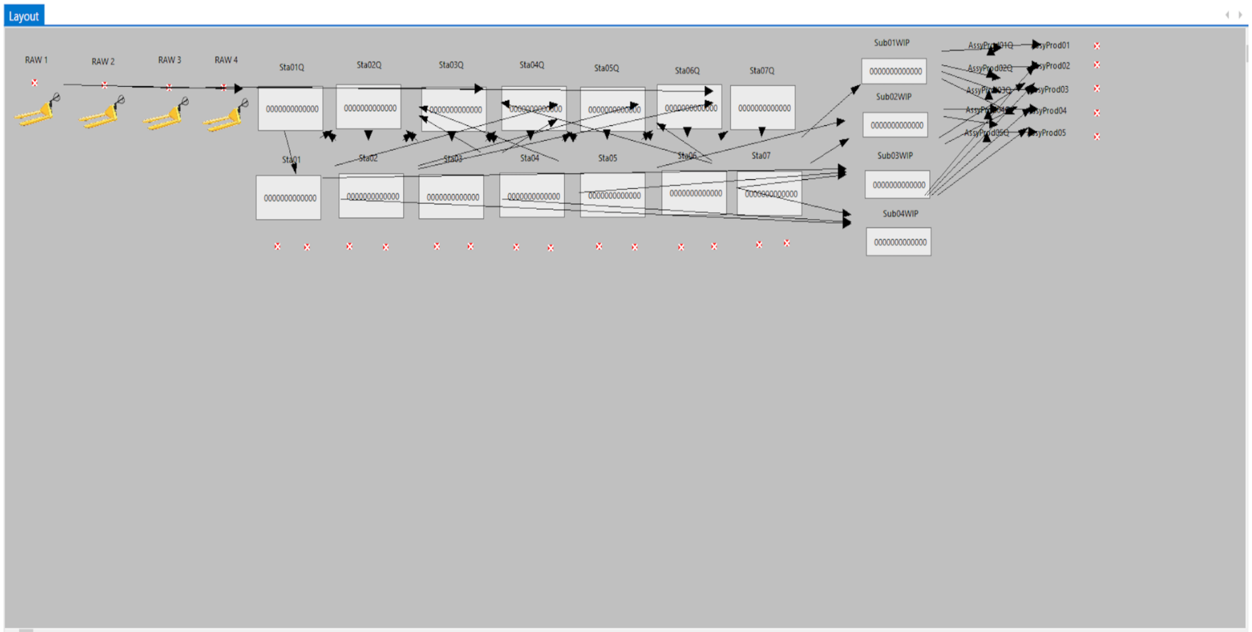

Figure 12.2

Tools | Operation | Move Logic

```
AL_Station = VR_Sta01
//create variable for vr_setup_station1  with initial value 0 (false)
//if station_1 is not setup for subprod 1 then wait setup time
//if variable is false then wait setup time
//       then set variable= true
//else if variable is true wait process time
If AE_SubAssyTyp = VR_SubProd01 And AL_Setup_SP01 = VR_No Then {
    Wait AY_SetupTime[1, AE_SubAssyTyp] min
    AL_Setup_SP01 = VR_Yes
}
Else If AE_SubAssyTyp = VR_SubProd02 And AL_Setup_SP02 = VR_No Then {
    Wait AY_SetupTime[1, AE_SubAssyTyp] min
    AL_Setup_SP02 = VR_Yes
}
Else If AE_SubAssyTyp = VR_SubProd03 And AL_Setup_SP03 = VR_No Then {
    Wait AY_SetupTime[1, AE_SubAssyTyp] min
    AL_Setup_SP03 = VR_Yes
}
Else If AE_SubAssyTyp = VR_SubProd04 And AL_Setup_SP04 = VR_No Then {
    Wait AY_SetupTime[1, AE_SubAssyTyp] min
    AL_Setup_SP04 = VR_Yes
}
Wait AY_ProcessTime[1,AE_SubAssyTyp] min
Route AE_SubAssyTyp
```

Arrays

ID	Dimensions	Type	Import File...	Export File...	
AY_ProcessTime	7, 4	Integer	D:\ProcessTime.xlsx		None
AY_SetupTime	7, 4	Integer	SetupTimes.xlsx		None

Figure 12.3

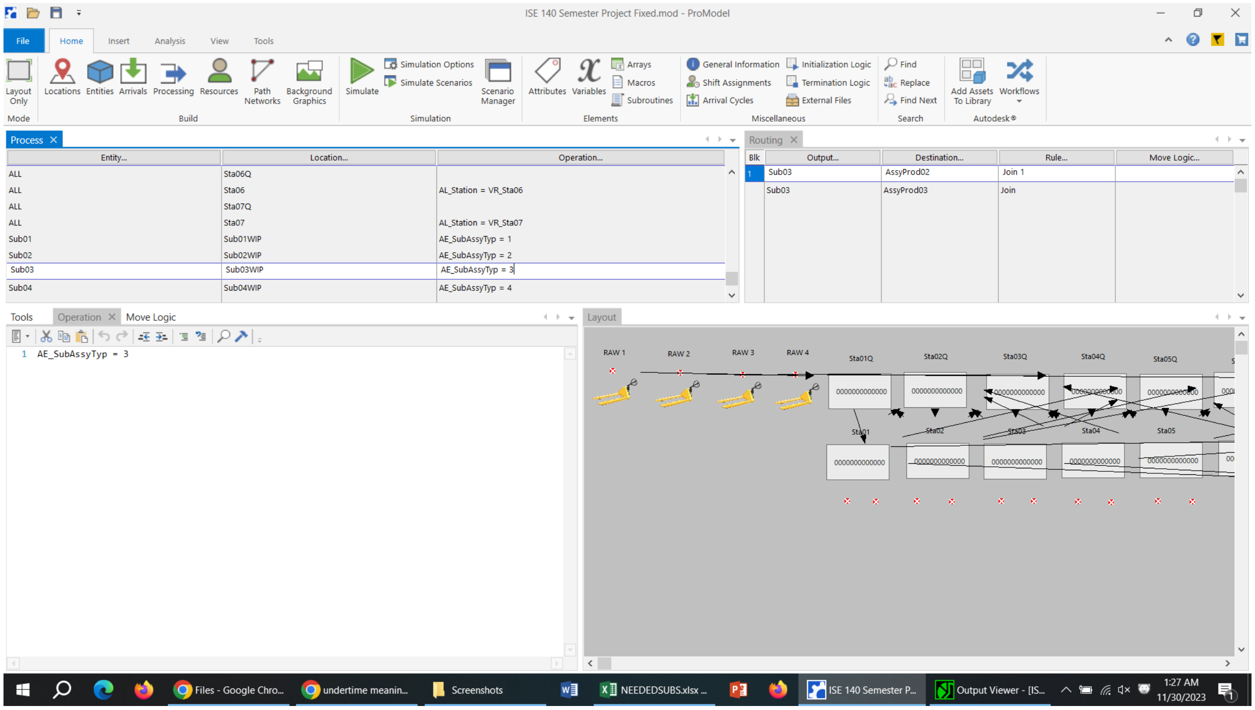

Figure 12.4

Locations | Clock

Icon	Name	Cap.	Units	DTs...	Stats	Rules...	Notes...
Aa	AssyProd04	INF	1	None	Time Series	Oldest	
Aa	AssyProd05Q	INF	1	None	Time Series	Oldest	
Aa	AssyProd05	INF	1	None	Time Series	Oldest	
00	Sta01Q	INF	1	None	Time Series	Oldest, FIFO	
Aa	Sta01	11	1	Clock,	Time Series	Oldest	
00	Sta02Q	INF	1	None	Time Series	Oldest, LIFO	
00	Sta02	7	1	Clock,	Time Series	Oldest	
Aa	Sta03Q	INF	1	None	Time Series	Oldest, FIFO	
00	Sta03	2	1	Clock,	Time Series	Oldest	
00	Sta04Q	INF	1	None	Time Series	Oldest, FIFO	
00	Sta04	5	1	Clock,	Time Series	Oldest	
00	Sta05Q	INF	1	None	Time Series	Oldest, FIFO	
00	Sta05	4	1	Clock,	Time Series	Oldest	
00	Sta06Q	INF	1	None	Time Series	Oldest, FIFO	
00	Sta06	3	1	Clock,	Time Series	Oldest	
00	Sta07Q	INF	1	None	Time Series	Oldest, FIFO	
00	Sta07	2	1	Clock,	Time Series	Oldest	
00	Sub01WIP	INF	1	None	Time Series	Oldest	
00	Sub02WIP	INF	1	None	Time Series	Oldest	
00	Sub03WIP	INF	1	None	Time Series	Oldest	
00	Sub04WIP	INF	1	None	Time Series	Oldest	
Aa	RAW_1	1	1	None	Time Series	Oldest	
Aa	RAW_2	1	1	None	Time Series	Oldest	
Aa	RAW_3	1	1	None	Time Series	Oldest	
Aa	RAW_4	1	1	None	Time Series	Oldest	

Figure 12.5

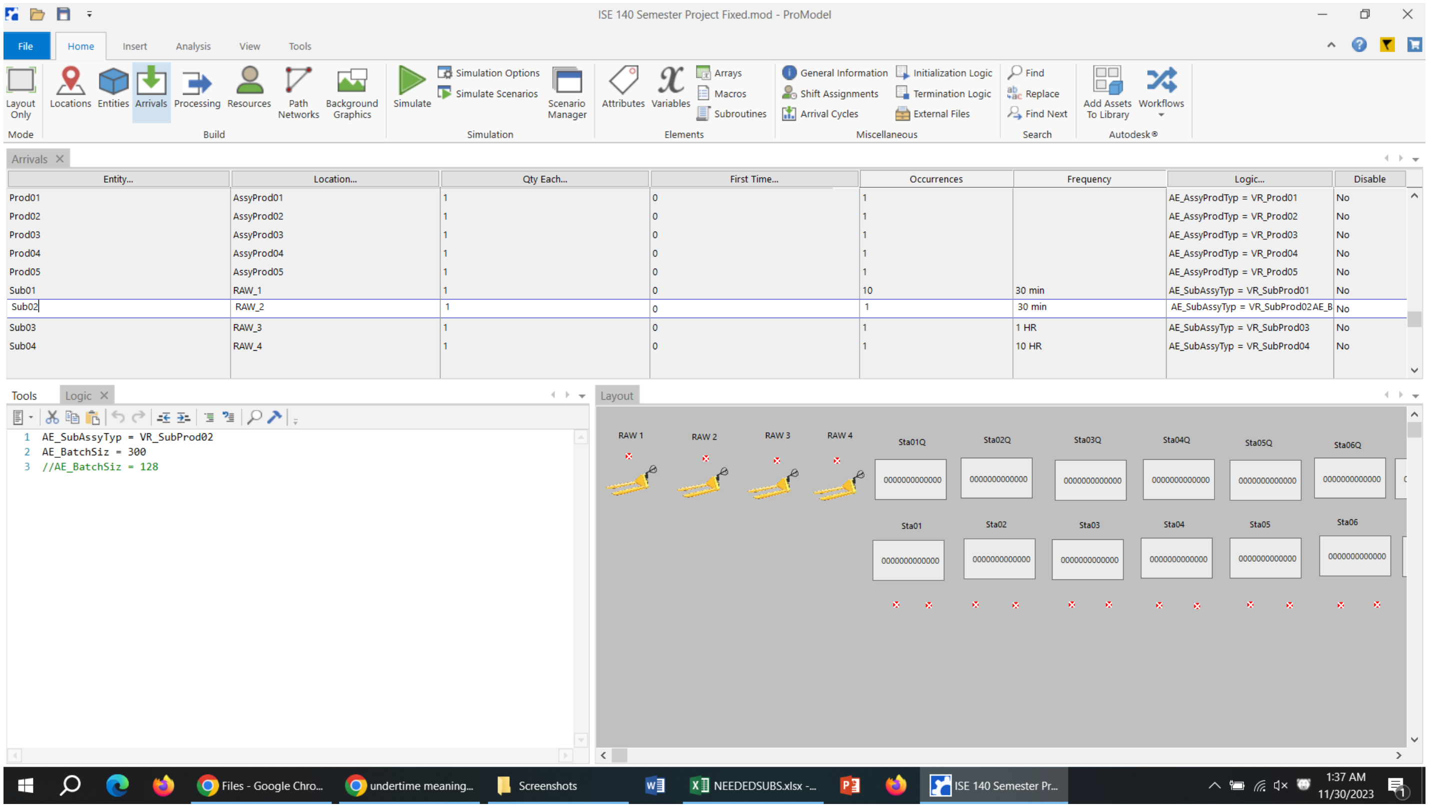

Figure 12.6

Report1 | Location Summary | Entity Summary | Variable Summary Table | Multiple Capacity Lo...n States Table | Variable Summary Table 1

Location Summary

Replication	Name	Scheduled Time (Hr)	Capacity	Total Entries	Average Time Per Entry (Min)	Average Contents	Maximum Contents	Current Contents	% Utilization
1	Sta01Q	480.00	999,999.00	13,247.00	13,470.38	6,195.91	12,717.00	0.00	0.62
1	Sta01	480.00	11.00	13,247.00	20.11	9.25	11.00	0.00	84.07
1	Sta02Q	480.00	999,999.00	14,886.00	450.79	233.00	946.00	0.00	0.02
1	Sta02	480.00	7.00	14,886.00	9.71	5.02	7.00	0.00	71.68
1	Sta03Q	480.00	999,999.00	13,247.00	12,530.95	5,763.80	10,533.00	10,233.00	0.58
1	Sta03	480.00	2.00	3,014.00	15.76	1.65	2.00	2.00	82.46
1	Sta04Q	480.00	999,999.00	4,154.00	972.05	140.20	1,634.00	0.00	0.01
1	Sta04	480.00	5.00	4,154.00	16.80	2.42	5.00	2.00	48.48
1	Sta05Q	480.00	999,999.00	4,949.00	1,342.56	230.71	691.00	0.00	0.02
1	Sta05	480.00	4.00	4,949.00	15.71	2.70	4.00	2.00	67.49
1	Sta06Q	480.00	999,999.00	4,150.00	69.37	10.00	60.00	2.00	0.00
1	Sta06	480.00	3.00	4,148.00	12.80	1.84	3.00	0.00	61.47
1	Sta07Q	480.00	999,999.00	4,345.00	2,414.79	364.31	717.00	396.00	0.04
1	Sta07	480.00	2.00	3,949.00	13.06	1.79	2.00	2.00	89.57

Figure 12.7

Report1 | Location Summary | Entity Summary | Variable Summary Table | Multiple Capacity Lo...n States Table | Variable Summary Table 1 | +

Entity Summary

Replication	Name	Total Exits	Current Quantity In System	Average Time In System (Min)	Average Time In Move Logic (Min)	Average Time Waiting (Min)	Average Time In Operation (Min)	Average Time Blocked (Min)
1	Sub01	1,275.00	11,175.00	18,360.11	0.00	18,217.47	111.23	31.41
1	Sub02	133.00	167.00	20,627.89	0.00	20,458.23	141.10	28.57
1	Sub03	492.00	5.00	26,706.44	0.00	26,609.36	75.31	21.77
1	Sub04	1,639.00	0.00	25,109.60	0.00	25,028.18	62.39	19.03