MIDDLE EAST TECHNICAL UNIVERSITY

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EM 599 - TERM PROJECT

FINAL REPORT

MONTE CARLO SIMULATION IN LOGISTICS PRICING

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1. INTRODUCTION

The aim of this project is to investigate and improve the present logistics operations of Constantia ASAŞ, Ankara. In this study; distribution strategy, logistics pricing and facility expansion will be covered. Throughout the investigation, the main objective is to provide a detailed and structured logistics analysis for the decision makers.

1.1. The Company – Constantia ASAŞ

ASAŞ was founded in 1978 by the Turkish entrepreneur Vural Baylan. Main product of ASAŞ was flexible packaging for consumer goods, such as snacks, chips, confectionery and so on (Figure 1). As ASAŞ had proven its superior quality and production capability; factory was purchased by the Constantia Flexibles Group in 2011. Now, the factory serves consumer goods producers in four continents.

Constantia Flexibles Group is one of the biggest flexible packaging producers for consumer goods and healthcare products. Although the group is based in Vienna, Austria; their products reach all over the world thanks to the 36 factories in 16 countries with more than 8000 employees.

Figure 1: Main product examples for ASAŞ

1.2. Problem Definition

In this study, customer and logistics firm names will be altered for the sake of corporate data protection.

As mentioned previously, ASAŞ has both domestic and foreign customers. ASAŞ has agreements with two different logistics firms to deliver finished goods, depending on whether the customer is domestic or foreign. For the domestic customers, the distribution is carried out by a firm named TransCo Logistics. The only exception for this is that several domestic customers prefer to use their own logistics firm. From now on, explanations and calculations will be for the domestic customers which ASAŞ uses TransCo Logistics for the deliveries.

By its nature, food manufacturers avoid having high inventory levels due to the spoilage. As a result of their just-in-time production mentality, they also avoid having a high level of raw material inventory in their stocks. To achieve this, they share the master production schedule with the suppliers and require bringing the production part by part in a large interval as needed. However, packaging film production is a continuous process. In other words, it requires high setup costs, time and work force. Therefore, ASAŞ prefers to produce the order in a single action, since it is much more cost saving. When ASAŞ produces the whole monthly demand in a single action, the need for warehousing appears because lots will be delivered at different dates. Yet, insufficient warehousing conditions are a downside for ASAŞ. The factory may not be able to store all the finished products depending on the seasons. For example, in Table 1, if ASAŞ prefers to produce the whole amount at once, it is needed to produce 9948 kg of goods on 22.08.2020 which is the first delivery. However, on this date only 949 kg of the production is required by the customer. Remaining lots must be stored in the depot until their arrival date comes.

Table 1. Delivery Schedule for a CoffiCo order

Order Number	Order Date	Customer	Total Amount Produced(kg)	Delivery Date	Delivery Amount(kg)
623363	10.07.2020	CoffiCo	9948.96	22.08.2020	948.6
				24.08.2020	4561.8
				25.08.2020	562.6
				28.08.2020	3185.52
				31.08.2020	258.56
				10.09.2020	431.88
				Total	9948.96

According to the agreement between ASAŞ and TransCo Logistics; TransCo is responsible for both transportation and mid-warehousing with its trucks and 6 warehouses in Turkey. ASAŞ pays 4500 TL for each delivery, regardless of how many pallets are loaded, distance and whether TransCo warehouse is used or not. For example, below 4 scenarios will be charged the same price:

- From ASAŞ to Eskişehir: 30 pallets will be delivered directly to customer A

- From ASAŞ to Eskişehir: 10 pallets will be delivered directly to customer A and then 20 pallets will be delivered to customer B. Both customers are in Eskişehir.
- From ASAŞ to İstanbul: 10 pallets will be delivered directly to the customer, but 20 pallets will be stored in TransCo warehouse in İstanbul until the final delivery.
- From ASAŞ to Gaziantep and Mersin: 10 pallets will be delivered directly to the customer in Gaziantep, but 10 pallets will be stored in the TransCo warehouse in Gaziantep. The remaining 10 pallets will be delivered directly to the customer in Mersin.

In the above examples; scenarios have different numbers of cities visited, different numbers of firms visited and also some scenarios include mid-warehousing. Since the price is fixed, it can be said that ASAŞ overpays for some of the scenarios or for all of them.

Although ASAŞ may use trucks to visit different cities and firms, if the number of visit points exceeds 3, ASAŞ pays an extra of 300 TL for each.

Since the pricing policy is quite uncertain, one may not claim whether ASAŞ overpaid or underpaid for these logistics services. Moreover, a company in Eskişehir(235 km to Ankara) and a company in Tekirdağ(715 km to Ankara) are equally job costed in this pricing. If the customer is located in a close city, its job costing should include less transportation cost. Otherwise, for the close cities, the customer is overcharged or ASAŞ gets lower profit. For either case, this policy is not fair and smart.

Why does ASAŞ need this study?

In the last few years, customer demand statistics have changed significantly. Customers tend to order smaller lots sizes to be able to minimize their inventory levels. In this case, ASAŞ should also adapt its logistics behavior accordingly to overcome the situation. The current pricing policy could be a reasonable agreement by the time; however, it needs to be investigated once again if it is still reasonable or no longer feasible. For this purpose, investigation should be fed by the current statistics and forecasts.

The aim of this project is to clarify logistics behavior and dynamics of ASAŞ, so that the decision makers will be able to negotiate with TransCo for a better deal. In the current situation, TransCo charges ASAŞ based on the number of trucks used and number of visit points above 3 of a single truck. However, how many times did ASAŞ exceed 3 visit points in a single truck? For example, if 90% of the deliveries have 4 or more visit points, in this case ASAŞ pays lots of extra money to the TransCo, which is not reasonable. Or maybe ASAŞ uses 90% of the trucks to deliver all the goods to a single visit point. In this case, why should ASAŞ negotiate for 3 visit points? In other words, ASAŞ's new agreement with TransCo should be based on the needs and behaviors of ASAŞ.

Of course, the decision making should rely on past statistics of ASAŞ in order to be realistic and reasonable. However, an important question is which statistics will be taken as the source. By the aid of the ERP system of the company; past sales data, past logistics data and past delivery data can be obtained. One may think that, since the aim is to improve logistics pricing, past logistics data can be a good guide. However, this will mislead the interpretation. Logistics executives in

ASAŞ, arrange deliveries in a way that cost is minimized for the current model. Therefore, the shipments can be said to be biased. In other words, if ASAŞ wants to change logistics mentality, then delivery gathering policy should be also changed accordingly. For example, since big and small trucks are charged the same price, ASAŞ tries to deliver the goods with big trucks as much as possible. For this purpose, ASAŞ produces the goods earlier than the required, maximizes the truck fullness and uses the TransCo warehouse for the storage. However, if small trucks were cheaper, then it could be considered for different models. On the other hand, when past logistics data is investigated, one may think that ASAŞ always uses big trucks, so it was not needed to take small trucks into account for the new model. Would it be meaningful and helpful for the next agreement?

It would be wiser to set sales data as the source to generate forecasts. By doing this bias will be eliminated from the solution.

This study is not only important to prove that there is a more profitable pricing policy, but also to improve ASAŞ's job costing.

1.3. Roadmap

To be able to understand the current situation deeply, deliveries should be simulated. By using previous years' sales records, future orders can be forecasted. By using Monte Carlo Simulation technique; random order times, amounts and sizes will be generated, from the past data by using computer software Python.

Depending on their location, cities have grouped into regions; Aegean, Marmara, South. Since the trucks may contain different firms' and cities' deliveries; the generated orders will be aggregated depending on the city and the region.

Obtained statistics will be used to decide optimal logistics strategy for ASAŞ. For the decision makers there will be 3 options with profit studies for each; going ahead with the current agreement, renting a warehouse near ASAŞ and building a new warehouse in the facility.

2. OVERVIEW

2.1. Customers

Nowadays, ASAŞ has more than 50 active Turkish customers in 12 different cities (Figure 2). Most of the customers produce food products and there are also several hygiene product manufacturers.

Some of the customers have a strong business cooperation with ASAŞ for over 30 years. But also, there are customers with inconsistent order behavior over the years. Approach throughout the project for each of them will be different.

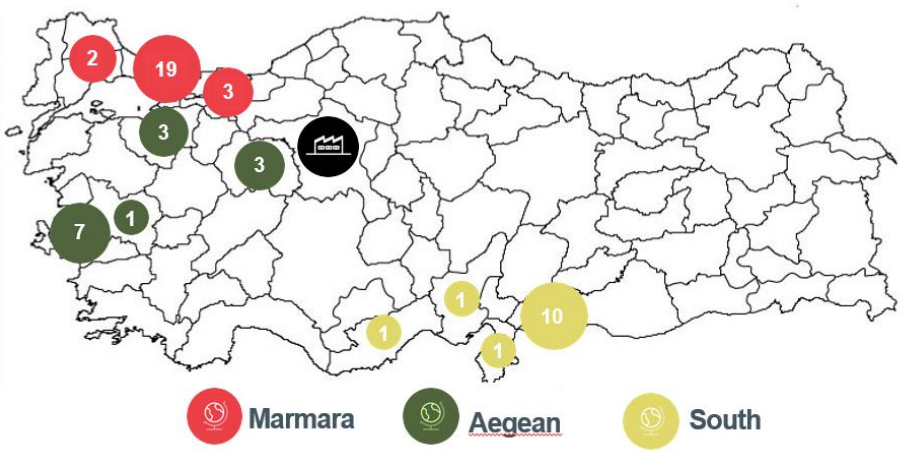

Figure 2: Customers and Regions

2.2. Demand

Although there is not a significant fluctuation in the demand for hygiene products, food products show extreme seasonality.

As mentioned above, food producers stick to a just-in-time mentality. In other words, food producers want to have the packages just before they start production. Therefore, demand for hot beverages in the food producer would not be different from the demand for its package in ASAŞ. In the wintertime, people are more likely to consume hot beverages, such as coffee (Figure 3). In Figure 3, it can be seen that there is an increase in the wintertime [1]. Similarly, one may expect to see an increase in ice-cream demand in the summer. Seasonality must be the main concern while generating the demand forecasts [2].

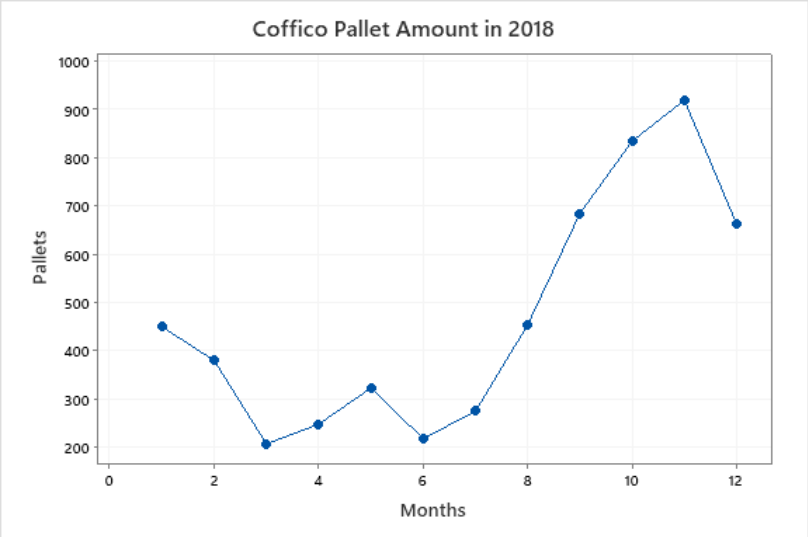

Figure 3: CoffiCo Turkey Coffee Demand in 2018

On the other hand, demand cannot be defined solely by seasonality. There are also yearly increases and decreases for the firms and the product groups (Figure 4). Firms may increase or

decrease their orders year by year as ASAŞ gains/losses their trust by its performance. Those factors should also be included [3].

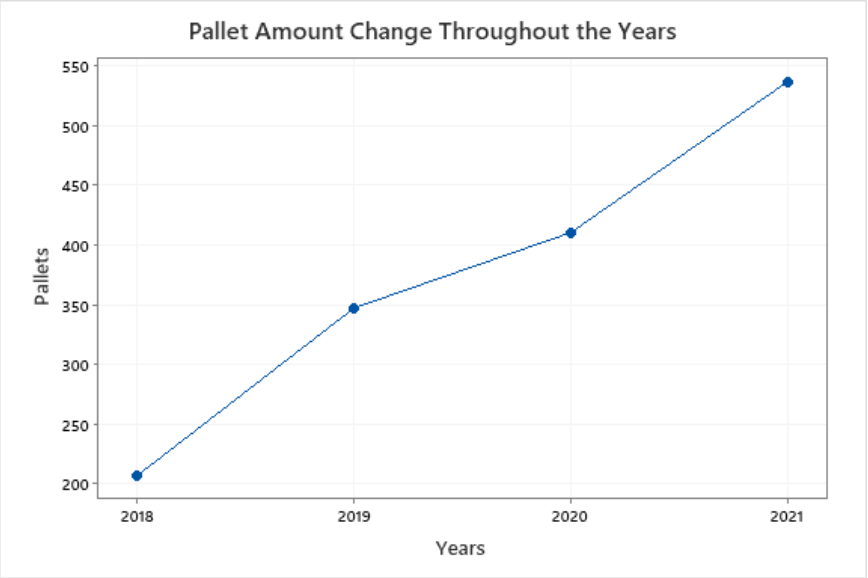

Figure 4: Pallet Amount Change for CoffiCo Turkey Throughout the Years

There are also sudden changes. In the Euro 2020 football tournament, Cristiano Ronaldo replaced Coca-Cola with a water bottle in press conference. This gesture may cause a change in Coca-Cola sales. Although the Coca-Cola sales will be higher again in the summertime than the winter, next year's summer sales can be expected to lower than the previous summer sales. Similarly, yeast products had a rapid increase after the pandemics because people tended to bake pastry in their home to avoid going out. This type of changes will be taken into account by manipulating the forecasts.

Interpreting the demand trend for big customers is easier. For example, ASAŞ has built a strong partnership with CoffiCo Turkey for years. ASAŞ is responsible for specific product groups for more than 20 years, so that the demand can be forecasted in terms of years and also seasons. There are two main CoffiCo products for ASAŞ: coffee and cereals. By looking at the total demand for them, meaningful data cannot be extracted. In the total graph, there is an increase starting in winter which lasts up to spring. Although it may look like a big bump; actually, there are two different peaks, winter for coffee and spring for cereals. In other words, each product group has their own seasonality. So, the remedy is to split product groups under the customer. To exactly know the behavior, the graphic should be evaluated separately.

In contrast, there are also small firms that come up with orders, after years with no appearance on the sales records. However, those small firms should also be included in the study because although their orders are inconsistent and small compared to big ones, the total of small firms should not be neglected. They are usually in Gaziantep or İstanbul, therefore they can be grouped and considered as a single firm. This manipulation will eliminate the fluctuation in the trend. Although they do not have a meaningful trend as single firms, aggregation of small firms can be a good indicator.

To be able to extract meaningful data from previous sales records, separation and aggregation will be used in the next chapters.

3. PROCEDURE

3.1. Tools

The study was started with extracting the sales record from the ERP system to the Microsoft Excel. However raw data was not ready to be processed because there were noise entries. By using Excel, raw data was cleansed.

Then, by putting raw data to Minitab, data visualization and distribution fitting was applied for the sales record.

In order to perform Monte Carlo Simulation, Python software is used. By using Minitab results and Python's Random module, random data has been generated. Generated data has been processed and extracted to the Excel for the final evaluation.

3.2. Generating Random Orders

At this point, it is needed to clarify the definition of order. Sometimes when ASAŞ receives an order, the order amount is the monthly total amount needed by the customer. However, most of the time customers want to receive the goods in several lots. For ASAŞ, producing the total amount in a single action is much more cost saving. As a result, when ERP system data is examined, it is observed that for each order number there are several delivery entries (Table 1). Therefore, it is hard to track and interpret by looking at orders data. Instead, it would be wiser to work on deliveries data. From now on, each delivery will be considered and identified as an order, for the ease of understanding.

As mentioned previously, for the food products seasonality is an important concern. Therefore, the intention is to investigate each customer while taking the month into account. To achieve this, Minitab's Decomposition of Time Series is used (Figure 5) [4]. This tool is fed by monthly order amounts(counts) of previous years (Table 2) to predict next year's amounts by months (Figure 6). What is good about this tool is that it can both include yearly trends and seasonality at the same time. Minitab fits an approximation to the distribution and gives error values for each previous month (Table 3). When those error values are put into Minitab's distribution fit tool, it was seen that error values follow normal distribution (Figure 7). In the end, by the aid of Minitab, order amounts can be randomly generated depending on the forecast and the error value which is coming from normal distribution (Table 4).

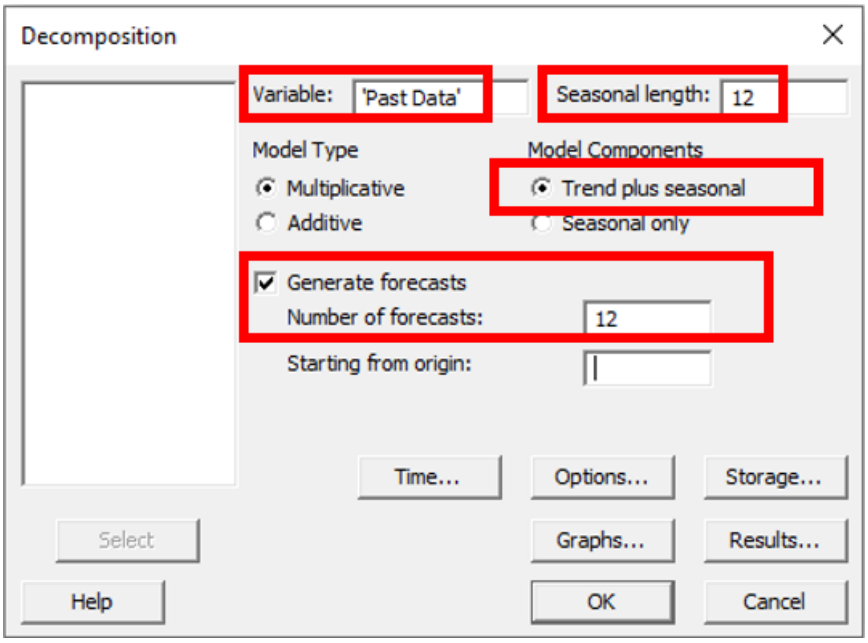

Figure 5: Minitab's Decomposition Tool

Table 2. Previous Order Amounts of Coffico

2018	Order Amount	2019	Order Amount	2020	Order Amount
Month 1	114	Month 1	108	Month 1	117
Month 2	77	Month 2	98	Month 2	83
Month 3	100	Month 3	83	Month 3	77
Month 4	78	Month 4	93	Month 4	102
Month 5	71	Month 5	81	Month 5	59
Month 6	69	Month 6	39	Month 6	66
Month 7	61	Month 7	76	Month 7	89
Month 8	102	Month 8	47	Month 8	118
Month 9	126	Month 9	79	Month 9	103
Month 10	143	Month 10	98	Month 10	111
Month 11	127	Month 11	59	Month 11	89
Month 12	96	Month 12	97	Month 12	95

Figure 6: Next Year Forecast for Coffico in Minitab Decomposition

Table 3. Error Values for the Previous Months

	Error Value for 2018	Error Value for 2019	Error Value for 2020
Month 1	-5.333	-9.654	1.024
Month 2	-16.620	5.698	-7.982
Month 3	17.129	1.298	-3.532
Month 4	-24.178	-7.736	2.706
Month 5	-4.313	6.751	-14.184
Month 6	13.405	-15.807	11.979
Month 7	-11.882	4.150	18.182
Month 8	26.561	-27.368	44.701
Month 9	20.451	-25. 049	0.449
Month 10	18.530	-24.699	-9.929
Month 11	33.255	-33.409	-2.075
Month 12	-5.593	-3.145	3.697

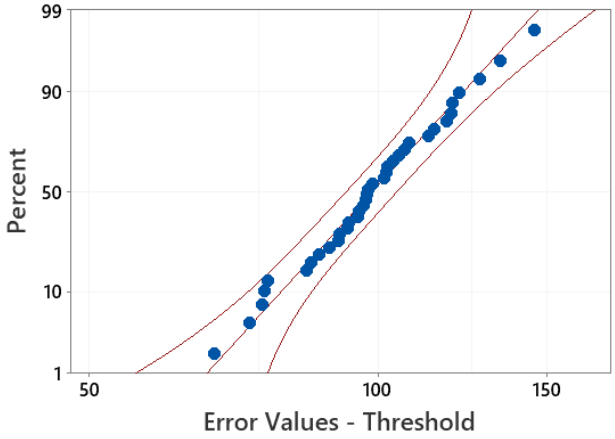

Figure 7: Probability Plot for Error Values

Table 4. Forecasted Order Amounts and Error Values for the Next Year

	Forecasted Order Amount	Error Value(μ;σ)
Month 1	114.2	(-0.831;17.393)
Month 2	89.66	(-0.831;17.393)
Month 3	79.36	(-0.831;17.393)
Month 4	97.85	(-0.831;17.393)
Month 5	72,11	(-0.831;17.393)
Month 6	53.23	(-0.831;17.393)
Month 7	69.78	(-0.831;17.393)
Month 8	72.22	(-0.831;17.393)
Month 9	101.05	(-0.831;17.393)
Month 10	119.15	(-0.831;17.393)
Month 11	89.74	(-0.831;17.393)
Month 12	97.24	(-0.831;17.393)

This action is repeated for all product groups and firms. After forecasting how many orders will be received, each order should be assigned the following dimensions: time and pallet amount. Although time is known in terms of month, it needs to be specified narrower. Narrower time assignment is crucial because deliveries in the same time interval and city will be gathered and loaded to the same truck. ASAŞ is able to strain production units to finish the goods several days earlier than planned. Similarly, the customers also allow ASAŞ to delay a delivery several days. So, orders in several days range can be gathered. For this project, a week is divided into two time intervals. Once the total number of orders is calculated for the customer and month, each order will be randomly assigned to one of eight intervals in the month (Figure 8).

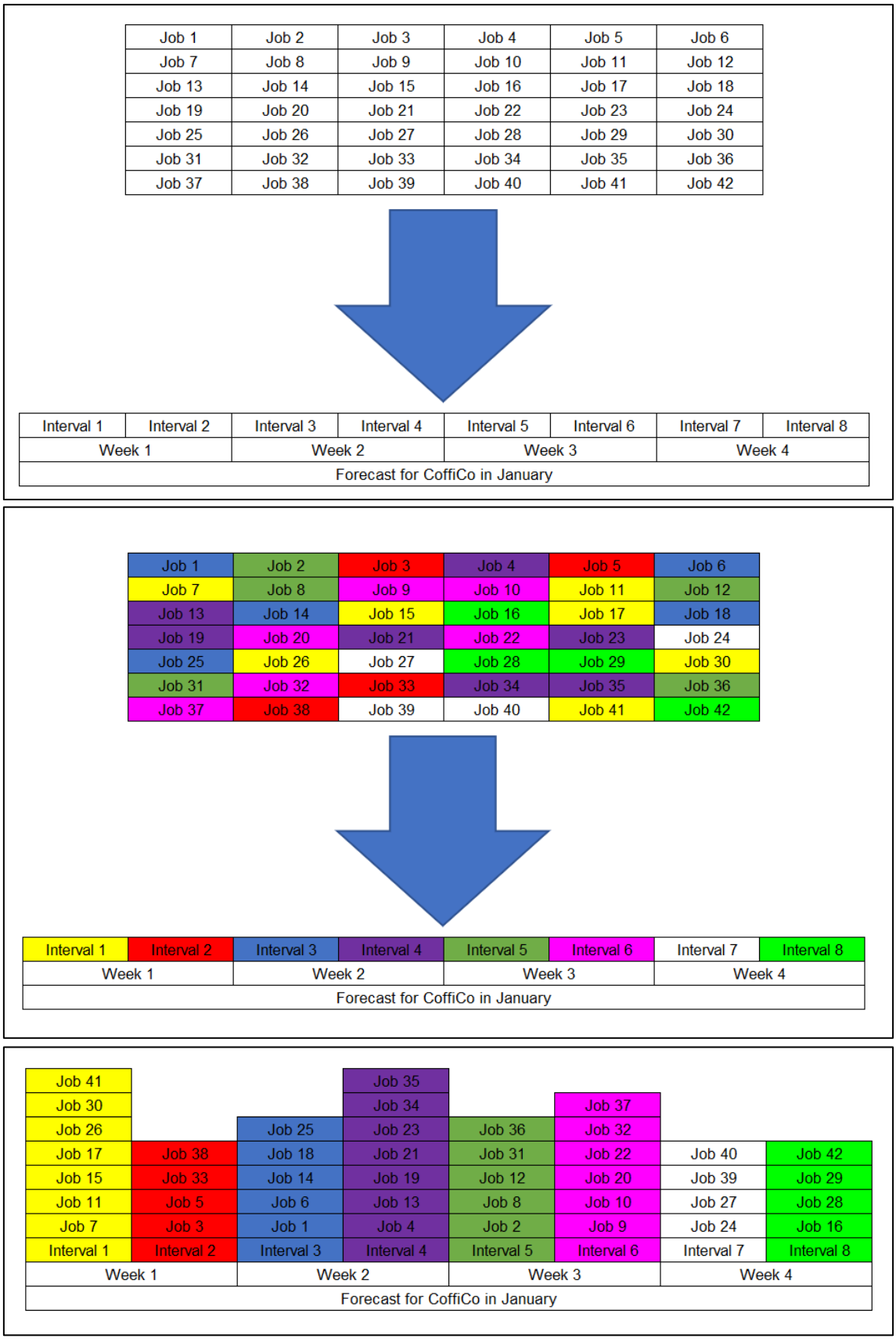

Figure 8: Random Distribution to the Intervals

In the next step, orders will be assigned pallet amount data. Approximate pallet amount in an order is 3, but it highly depends on firm characteristics and seasonality. Thus, pallet amount data should be generated from the respective firm and month. For example, the algorithm collects past January orders for CoffiCo Turkey, then creates probabilities of pallet amounts occurrence (Table 5).

What percentage of orders were 1 pallet in January for CoffiCo Turkey?
What percentage of orders were 2 pallets in January for CoffiCo Turkey?
…

Table 5. Probabilities of Pallet Amounts Occurrence

Pallet Amount	Counts	Percentage
1	28	8.3 %
2	66	19.6 %
3	51	15.2 %
4	58	17.3 %
5	28	8.3 %
6	29	8.6 %
7	22	6.5 %
8	9	2.7 %
9	9	2.7 %
10	7	2.1 %
11	7	2.1 %
12	2	0.6 %
13	7	2.1 %
14	3	0.9 %
16	3	0.9 %
17	2	0.6 %
18	2	0.6 %
20	1	0.3 %
21	2	0.6 %

Those percentages will be decisive while generating an order in next year's January for CoffiCo Turkey. For a given pallet amount; the more previous occurrence, higher the probability of assigning the future forecast with this pallet amount. Each future order will be assigned based on those percentages and afterwards, it's likely to see similar percentages.

3.3. Gathering the Orders

After generating orders with the pallet amount and interval information, orders are tabulated in a summary list(Table 6).

Table 6. Generated Orders with Detailed Information

Order No	Firm	City	Region	Month	Interval	Pallet Amount
J51	CoffeCo	Bursa	Aegean	2	10	10
J52	CoffeCo	Bursa	Aegean	2	10	7
J53	CoffeCo	Bursa	Aegean	2	10	5
J54	CerealCo	Bursa	Aegean	2	10	12
J55	CerealCo	Bursa	Aegean	2	10	8
J56	CerealCo	Bursa	Aegean	2	10	7
J57	CerealCo	Bursa	Aegean	2	10	6
J58	CerealCo	Bursa	Aegean	2	10	5
J59	CerealCo	Bursa	Aegean	2	10	3
J60	CerealCo	Bursa	Aegean	2	10	1
J61	CerealCo	Bursa	Aegean	2	10	1
J62	CerealCo	Bursa	Aegean	2	10	1
J63	ChocoStars	Eskişehir	Aegean	2	10	2
J64	ChocoStars	Eskişehir	Aegean	2	10	2
J65	ChocoStars	Eskişehir	Aegean	2	10	1
J66	ChocoStars	Eskişehir	Aegean	2	10	3
J67	ChocoStars	Eskişehir	Aegean	2	10	1
J68	ChocoStars	Eskişehir	Aegean	2	10	1
J69	ChocoStars	Eskişehir	Aegean	2	10	1
J70	ChocoStars	Eskişehir	Aegean	2	10	1

Trucks may carry different orders if the delivery dates and locations are close to each other. As described earlier; to be able to define “close date”, time intervals were created and a time interval is one half of a week.

Big trucks are able to carry 33 pallets, and small ones 18. Algorithm starts with the city which has the highest total amount of pallets to be able to minimize the total city visit amount. If there is an empty space for more pallets, the algorithm looks for another firm in the same city. If the truck is not full again, gathering continues with the firms in different cities but in the same region.

In Table 6, algorithm starts with the CerealCo orders which has the highest number of pallets in total. First four orders of CerealCo J54, J55, J56, J57 have a total of 33 pallets, which can be gathered in a big truck. Algorithm will continue with the same firm, so J58, J59, J60, J61, J62 will be gathered. However, the sum of those orders is 11 pallets. Thus, gathering continues with CoffiCo which is in the same city as CerealCo. CoffiCo orders; J51, J52 and J53 have a total of 22 pallets. When combined with remaining CerealCo pallets, a total of 33 pallets will be delivered with another big truck. Remaining orders belong to ChocoStars which is in Eskişehir. Summation of the pallets for ChocoStars is 14, which can be delivered with a small truck.

To be able to interpret the results, gathered deliveries are tabulated in a summary list (Table 7). Each line represents a gathered delivery plan, in other words a truck. In Table 7; distance, number of cities visited, number of firms visited and pallet amount can be seen.

Table 7. Gathered Truck Information for Replication 1

Truck No	Truck Type	Total Size	Truck Capacity	% Fullness	Distance	# of Cities	# of Firms	Region	Interval
Truck1	Big	33	33	100	387	1	1	Aegean	10
Truck2	Big	33	33	100	387	1	2	Aegean	10
Truck3	Small	14	18	78	387	1	1	Aegean	10
Truck4	Big	32	33	96	487	2	8	Aegean	10
Truck5	Big	21	33	63	345	1	1	Aegean	10
Truck6	Small	11	18	61	918	2	3	Aegean	10
Truck8	Big	31	33	95	387	1	1	Aegean	10
Truck9	Big	32	33	96	387	1	1	Aegean	10
Truck10	Big	23	33	69	733	2	3	Aegean	10
Truck11	Big	32	33	96	477	1	2	Aegean	10
Truck12	Big	31	33	93	477	1	4	Aegean	10
Truck13	Big	27	33	81	487	2	2	Aegean	10
Truck14	Big	27	33	81	706	1	1	Aegean	10
Truck16	Big	32	33	95	387	1	1	Aegean	10
…	…	…	…	…	…	…	…	…	…
Truck612	Big	27	33	81	706	2	2	South	96

Above calculations are made for a year simulation. So, in the first simulation year, 612 trucks are used.

3.4. Summarizing a Year Simulation

Up to now, all the calculations have been made to simulate a year. However, the process involves lots of randomness in the parameters. Therefore, it is needed to re-run the simulation many times. In this project, simulation has been repeated 5,000 times and recorded.

4.RESULTS

4.1. Rendered Parameters

During the simulation, parameters have been rendered to understand dynamics of the phenomena. As mentioned above, each line involves summarized data of a year simulation. Therefore, Table 7 will be a line in Table 8. Also, in Table 9, there are summary statistics for each column.

Table 8. 5000 Replications of the Simulation

	Trucks					Cities Visited %			Firms Visited %						
Year Simulation	Total #	% Big	% Small	Total Pallets	Avr. Distance (km)	1	2	3	1	2	3	4	5	6	7 or Higher
1	612	77	23	19034	583	63	33	2	24	30	19	11	4	4	4
2	641	75	25	19605	580	64	32	2	28	26	20	10	5	3	4
3	643	76	24	20350	576	64	32	2	27	27	22	8	5	3	4
4	617	74	26	18298	576	65	31	3	22	30	21	10	6	3	4
5	642	78	22	20589	581	64	32	3	26	25	21	10	5	5	4
6	642	75	25	20145	583	64	32	3	25	29	19	11	4	4	4
7	635	76	24	19847	583	64	31	4	24	27	22	10	5	5	4
8	646	78	22	20018	588	63	33	3	24	28	21	11	6	3	4
9	607	75	25	18645	581	59	34	5	24	25	21	12	5	6	4
10	629	73	27	19300	571	63	33	3	26	28	19	11	5	4	4
11	639	75	25	19729	576	64	32	2	25	29	19	11	5	4	4
…	…	…	…	…	…	…	…	…	…	…	…	…	..	…	…
5000	636	76	24	18976	567	63	33	2	24	25	21	12	6	5	4

Table 9. Summarized Parameters for 5000 Replications

Parameter	**Mean and Std. Dev.**
Total Number of Vehicles	628.7±16.4
%Big Truck	75.9±1.3
%Small Truck	24.1±1.3
Pallet Amount	19561.7±601.6
Total Distance	12,307,118±679,188 km
Average Distance of a Truck	580±4.8 km
1 City Visited %	62.6±1.8
2 Cities Visited %	32.9±1.7
3 Cities Visited %	2.9±0.9
1 Firm Visited %	25.6±1.6
2 Firms Visited%	26.8±1.7
3 Firms Visited%	20.4±1.6
4 Firms Visited%	10.3±1.4
5 Firms Visited%	5.3±0.9
6 Firms Visited%	4.2±0.7
7 or Higher Firms Visited %	3.9±0.9

5. SCENARIOS

5.1. Decision Making for Warehouse

As stated earlier, the current agreement with the logistics firm also involves warehousing price. Since ASAŞ's warehouse is not sufficient to store all the finished goods, TransCo warehouses are utilized for the goods that await delivery to the customer. In Table 10, TransCo's fee for different cities information is shown. This price information is valid solely for the transportation operations. Average of the ratios will be used in the final calculations. Simulations suggest that if ASAŞ pays per km price, it would be much more cost saving. However, one should also keep in mind that ASAŞ will face warehousing fees for each pallet/delivery. To eliminate this downside, ASAŞ must consider two options; building a new warehouse in the facility or renting a depot near the facility to warehouse the goods.

Table 10. TransCo Fee Table

	Distance(km)	Fee(TL)	Price per Distance(TL/km)
İstanbul	543	2700	4.972
Tekirdağ	618	2975	4.814
İzmir	614	2750	4.479
Bursa	495	2175	4.394
Gaziantep	751	3400	4.527
Mersin	555	2375	4.279
Adana	548	2375	4.334
		Avr.	4.543

Warehouse planning is not only important for the goods stored in TransCo's depot, but also important for all finished products, raw material and equipment. ASAŞ already rented a warehouse to keep its equipment. Similarly, raw material storage is a real struggle. Therefore, warehouse planning may also include these three important components. However, this is out of scope of this study.

ASAŞ can already store 600 pallets in the current facility. However, there are also other customers which are not included in this study. Therefore, ASAŞ can only spare 300 pallets capacity for this study. In Table 11, pallet information for the last 3 years can be seen. On average, ASAŞ must store 681 pallets daily. In the extreme case, ASAŞ stored 1150 pallets on the same day. Therefore, ASAŞ needs more places to store more pallets.

Table 11. Pallet Storage Data

Type	Amount
Average Pallet Amount Stored in a Day	681
Maximum Pallet Amount Stored in a Day	1150
Minimum Pallet Amount Stored in a Day	172
Maximum Daily Amount Palletized	142
Average Amount Palletized in a Day	42
Average Amount Departed in a Day	43

5.2. Renting a Warehouse Near to the Facility

According to market research for warehouse renting. ASAŞ will pay 5 TL for each entry/exit of a pallet. Also, to transfer those pallets from facility to warehouse, ASAŞ will pay 400 TL.

ASAŞ will use this warehouse to store 15,000 pallets annually. For entry and departure ASAŞ will pay 10x15,000=150,000 TL. Also, for the transfer, 470 trucks will be used which will cause 188,000 TL. Also, the building renting price will be 20,000TL per month.

All in all, ASAŞ will pay 578,000 TL for renting a warehouse near to the facility (Table 12).

Table 12. Components of Rental Cost

	Operation	Cost (TL)
Entry-Exit	15,000 pallets x 10 TL / pallet	150,000
Mid-Warehouse Transfer	15,000 pallets x 400 TL / 33 pallets	188,000
Rent	20,000 TL / month x 12 months	240,000
	Total	578,000

5.3. Building a New Warehouse

ASAŞ may also consider building a new warehouse in the existing facility. On average, ASAŞ needs more space to store the remaining 381 pallets. However, satisfying average needs may not be sufficient because in the peak time, there may be 800 more pallets to be stored. In fact, new building calculations can be made for 800 pallets because it can also help for raw material storage needs. Market research suggests that building a warehouse with 800 pallets capacity is 3,000,000 TL. However, in this option, transportation cost and entry/exit price will be eliminated, so that it is also reasonable.

6. DISCUSSION

6.1. Decision Making for Renting a Warehouse Near to the Facility

There are 2 cost components for the renting option; Distance Based Transportation Cost and Overall Rental Cost. Sum of these two components will be subtracted from the current agreement cost to see savings. This calculation will be performed for each line, in other words each replication.

a. **Current Agreement Column**: Total number of vehicles is multiplied with 4500 TL, since for each truck ASAŞ pays that amount. In addition to that, if the number of visit points exceeds 3, ASAŞ pays 300 for each extra point.

For example for the Replication 1 (Table 13):

Table 13. Cost Components for the Replication 1.

	Operation	Cost (TL)
Truck Costs	(612 Trucks) x (4500 TL / Truck)	2,754,000
Extra 1 Visit Point Cost	(612 Trucks) x (11%) x (300 TL) x 1	20,196
Extra 2 Visit Points Cost	(612 Trucks) x (4%) x (300 TL) x 2	14,688
Extra 3 Visit Points Cost	(612 Trucks) x (4%) x (300 TL) x 3	22,032
Extra 4 or Higher Visit Points Cost	(612 Trucks) x (4%) x (300 TL) x 4	29,376
	Total	2,840,292

b. **Distance Based Cost Column**: According to Table 10, ASAŞ will pay 4.543 TL for each kilometer. Therefore for Replication 1 (Table 14):

Table 14. Distance Based Pricing for the Replication 1

	Operation	Cost
Distance Based	(612 Trucks) x (583 km) x (4.543 TL / km)	1,620,924 TL

c. **Overall Renting Cost Column**: In section 5.2., overall cost is calculated to be 578,000 TL. It is assumed to be constant for each replication.

Table 15. Savings for the Renting Option

Year Simulation	Total # Vehicle	Avr. Distance	4 Firms %	5 Firms %	6 Firms %	7 or Higher Firms %	Current Agreement Cost (TL)	Distance Based Cost (TL)	Overall Renting Cost (TL)	Saving (TL)
1	612	583	11	4	4	4	2,840,292	1,620,924	578,000	641,368
2	641	580	10	5	3	4	2,971,035	1,688,996	578,000	704,038
3	643	576	8	5	3	4	2,976,447	1,682,581	578,000	715,865
4	617	576	10	6	3	4	2,863,497	1,614,545	578,000	670,951
5	642	581	10	5	5	4	2,987,226	1,694,548	578,000	714,678
6	642	583	11	4	4	4	2,979,522	1,700,383	578,000	701,141
7	635	583	10	5	5	4	2,954,655	1,681,841	578,000	694,814
8	646	588	11	6	3	4	3,000,024	1,725,649	578,000	696,375
9	607	581	12	5	6	4	2,833,476	1,602,166	578,000	653,310
10	629	571	11	5	4	4	2,922,963	1,631,659	578,000	713,304
11	639	576	11	5	4	4	2,969,433	1,672114	578,000	719,318
…	…	…	…	…	…	…	…	…	578,000	…
5000	636	567	12	6	5	4	2,966,940	1,681,600	578,000	707,339

Approximate annual savings will be 687,820 ± 34,644 TL.
95% Confidence Interval : (686,860 TL - 688,780 TL)

6.2. Decision Making for Building a New Warehouse

For building a new warehouse option, rental cost will be eliminated. Therefore, from Table x, the overall renting cost column will be removed to find savings for this option. Rest of the calculations will be the same with the rental option (Table 16).

Approximate annual savings will be 1,265,820 ± 34,644 TL.
95% Confidence Interval : (1,264,860 TL – 1,266,780 TL)

However, since building a new warehouse requires a capital investment, the project should also include a financial report for the credit option (Table 17) [5].

Table 16. Savings for the Building Option

Year Simulation	Total # Vehicle	Avr. Distance	4 Firms %	5 Firms %	6 Firms %	7 or Higher Firms %	Current Agreement Cost (TL)	Distance Based Cost (TL)	Saving (TL)
1	612	583	11	4	4	4	2,840,292	1,620,924	1,219,368
2	641	580	10	5	3	4	2,971,035	1,688,996	1,282,038
3	643	576	8	5	3	4	2,976,447	1,682,581	1,293,865
4	617	576	10	6	3	4	2,863,497	1,614,545	1,248,951
5	642	581	10	5	5	4	2,987,226	1,694,548	1,292,678
6	642	583	11	4	4	4	2,979,522	1,700,383	1,279,141
7	635	583	10	5	5	4	2,954,655	1,681,841	1,272,814
8	646	588	11	6	3	4	3,000,024	1,725,649	1,274,375
9	607	581	12	5	6	4	2,833,476	1,602,166	1,231,310
10	629	571	11	5	4	4	2,922,963	1,631,659	1,291,304
11	639	576	11	5	4	4	2,969,433	1,672114	1,297,318
…	…	…	…	…	…	…	…	…	…
5000	636	567	12	6	5	4	2,966,940	1,681,600	1,285,339

Table 17. Investment Return Plan for the Building Option

	Saving (TL)	Beginning Debt (TL)	Interest (TL)	Total Debt (TL)	Remaining Debt (TL)
At the End of Year 1	1,265,820	3,000,000	510,000	3,510,000	2,244,180
At the End of Year 2	1,265,820	2,244,180	381,510	2,625,690	1,359,870
At the End of Year 3	1,265,820	1,359,870	231,178	1,591,048	325,228
At the End of Year 4	1,265,820	325,228	55,288	380,517	-885,302
At the End of Year 5	1,265,820	-	-	-	-

7. CONCLUSION

In the study, the goal was to deeply understand the logistics parameters and structures of ASAŞ. In the current agreement, ASAŞ uses both TransCo's transportation service and TransCo's warehouses. In the new agreement, ASAŞ wants to use TransCo logistics solely for transportation. However, to make smart offers, ASAŞ needs to understand its logistics dynamics deeply.
Statistics in the project can enlighten ASAŞ, while negotiating for the price with TransCo Logistics. It can be said that, by the aid of the results obtained, ASAŞ will be able to make wiser decisions. In addition to transportation pricing, ASAŞ needs to investigate warehousing problems with two options. ASAŞ needs to create more space for warehousing other than TransCo's warehouses. ASAŞ may rent a new warehouse near the facility or construct a new warehouse building in the facility. In this report, both transportation pricing and warehousing feasibility studies for options were investigated. Then, the findings are combined to have meaningful insights.

For the renting option, ASAŞ will use a rental warehouse near the facility to store the goods that will be shipped by TransCo. The downside for the rental option is that ASAŞ needs to pay entry/exit costs, rental fee and transfer cost from the facility to the rental warehouse. All in all, it is still much more cost saving than the current model and does not require any capital investment. However, although it is reasonable financially, it will be a recurring expense for ASAŞ by its rental fee and operating costs. On the other hand, what is good about this option is that ASAŞ will start to save money immediately which is 687,820 TL per year.

In contrast to the rental option, ASAŞ needs to pay 3,000,000 TL for capital investment for building a new warehouse. However, ASAŞ will get rid of important operating expenses such as; entry/exit and transfer costs. By this option, ASAŞ will save 1,265,820 TL per year. If ASAŞ follows a financial plan that 3,000,000 credit to be repaid each year with the saving, within the fourth year ASAŞ will recoup its investment.

Both options will be presented to the company EVP.

8. REFERENCES

1. Russell, R., & Taylor, B. (2011). Lean Systems. In *Operations Management* (Seventh Edition) , John Wiley & Sons Ltd.
2. Thomopoulos, Nick. (2015). Seasonal Forecasts. 10.1007/978-3-319-11976-2_5.
3. Calichman, Murray. (2019). Forecasting Resource Needs: Trend Lines and Seasonality. 10.1007/978-3-030-16365-5_9.
4. Minitab Inc. (2000). 7-10. In *MINITAB user's guide 2: Data analysis and quality tools*. essay.
5. Newman, D. G., Eschenbach, T. G., & Lavelle, J. P. (2004). *Engineering economic analysis*. Oxford Univ. Press.