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1. Introduction

The principle purpose of this report is to propose efficient solutions to Berlin Brewery in terms of Supply chain design and management. As for this reason, we adopt Greenfield analysis, network optimization, and simulation techniques. Results from such methods would be summarized into managerial insights and transformed into recommendations for the company leaders.

2. Supply chain analysis

2.1. Greenfield analysis

Greenfield Analysis is used while establishing a novel supply chain facility in a previously undeveloped area. The word "greenfield" originates from the construction industry and refers to a pristine location that is fully prepared for development (Alinezhad et al. 2022). The objective is to resolve the facility placement quandary by identifying the most advantageous location for a new facility or distribution hub. Greenfield Analysis (GFA) or Center of Gravity Analysis is used to compare an existing network with an ideal blue-sky framework - a creative and optimum model unrestricted by present constraints (Bilgen and Ozkarahan 2004). This approach provides a potent means to see the potential of constructing a supply chain without being limited by preexisting frameworks (Che 2017). It is often used during the first phases of supply chain network planning.

After recognizing the issue, which is the expensive nature of transportation and its detrimental effects on the environment, supply chain manager may commence the process of investigating potential remedies (Sheibani and Niroomand 2024). As a seasoned supply chain management expert, the supply chain manager acknowledges that minimizing the distance between the firm and the client may result in decreased transportation costs and emissions (Ahmadi-Javid and Hoseinpour 2015). Despite its seeming simplicity, it is not feasible for the firm to construct a distribution center (DC) in every area. A Greenfield Analysis may assist in determining the most suitable quantity and positions of distribution centers to effectively cater to client needs, taking into account factors such as demand, customer locations, goods, and distances to and from the distribution centers (Gao et al. 2024; Nagahara et al. 2023).

The process of choosing a new distribution center location utilizes the principle of Greenfield Analysis (GFA), which is sometimes referred to as center of gravity analysis, in the design of supply chain networks (Nishi et al. 2020). GFA is a frequently used method in the first phases of supply chain planning to determine the most advantageous quantity and placements of manufacturing facilities and/or distribution hubs. The objective of GFA is to efficiently fulfill a network of client requirements while minimizing costs. GFA assists the organization in developing a supply chain network that is characterized by efficiency, adaptability, and responsiveness to changes (H. Wang and Jin 2020; Liu et al. 2023). Through the implementation of strategic supply chain decisions, it provides several advantages. As for this reason, the author tests two scenarios in which Berlin Beer establishes 2 or 7 new DC respectively.

2.1.1. 2 sites

The following figure depicts locations of the two new distribution center.

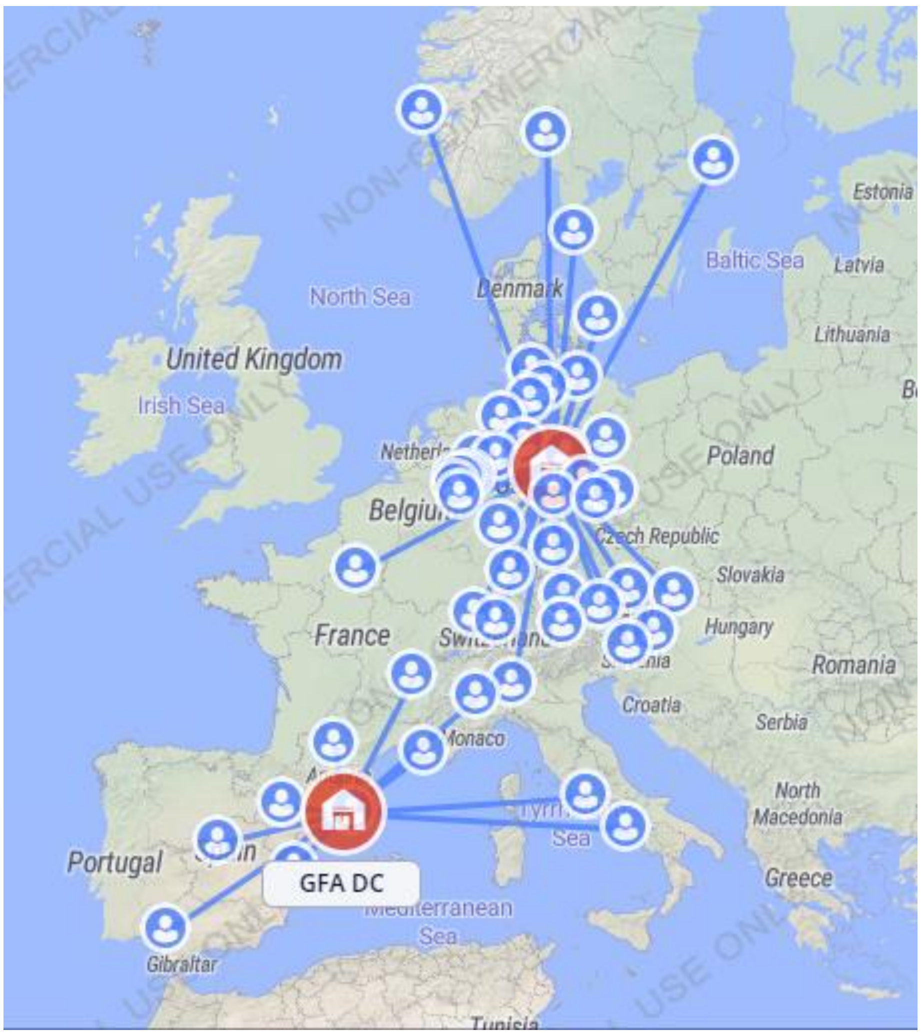

Figure 2-1: Location of two new DC

One is located in Berlin, and the other will be developed in Spain. The estimated flows, distance to sites, and logistic cost are summarized in the table below:

Table 2-1: Estimated product flows of 2 DCs

Cities	All			Summer period			Winter period		
	Flows	**Distance**	**Cost estimation**	**Flows**	**Distance**	**Cost estimation**	**Flows**	**Distance**	**Cost estimation**
Vienna	437.45	1,111.22	243,051.89	253.50	555.61	140,847.31	183.95	555.61	102,204.58
Stockholm	235.30	1,917.67	225,614.11	136.50	958.84	130,881.12	98.80	958.84	94,733.00
Rome	189.15	1,781.16	168,453.60	109.85	890.58	97,830.44	79.30	890.58	70,623.16
Madrid	338.65	945.34	160,069.88	196.30	472.67	92,785.23	142.35	472.67	67,284.65
Berlin	820.30	382.74	156,981.62	475.80	191.37	91,054.31	344.50	191.37	65,927.30
Munich	338.00	802.65	135,648.35	196.30	401.33	78,780.39	141.70	401.33	56,867.96
Gothenburg	172.25	1,340.76	115,473.10	100.10	670.38	67,105.13	72.15	670.38	48,367.98
Paris	153.40	1,370.58	105,123.53	89.05	685.29	61,025.10	64.35	685.29	44,098.43
Hamburg	416.65	425.92	88,730.05	241.80	212.96	51,493.89	174.85	212.96	37,236.17
Cologne	247.65	573.82	71,052.79	143.65	286.91	41,214.35	104.00	286.91	29,838.44
Naples	63.70	2,091.57	66,616.48	37.05	1,045.79	38,746.32	26.65	1,045.79	27,870.16
Milan	88.40	1,417.62	62,658.95	51.35	708.81	36,397.48	37.05	708.81	26,261.47
Oslo	67.60	1,829.53	61,838.09	39.00	914.77	35,675.82	28.60	914.77	26,162.27
Seville	74.10	1,605.19	59,472.32	42.90	802.60	34,431.34	31.20	802.60	25,040.98
Stuttgart	144.30	694.52	50,109.27	83.85	347.26	29,117.55	60.45	347.26	20,991.72
Toulouse	32.50	502.21	8,160.96	18.85	251.11	4,733.36	13.65	251.11	3,427.60
Barcelona	171.60	67.73	5,811.60	99.45	33.87	3,368.09	72.15	33.87	2,443.51
Erfurt	48.10	167.40	4,025.93	27.95	83.70	2,339.39	20.15	83.70	1,686.54
Magdeburg	54.60	138.60	3,783.74	31.85	69.30	2,207.18	22.75	69.30	1,576.56
Grand Total	**6,509.10**	**41,234.82**	**2,492,103.65**	**3,762.85**	**20,617.41**	**1,443,495.84**	**2,746.25**	**20,617.41**	**1,048,607.81**

At first glance, the annual product flows are 6,509.10; in which the larger proportion takes place in summer with 3,762.85 flows owing to rising demand of brewery product. In the Winter period, falling demand drives the product flows to 2,746.25 only. The total travelling distance amounts to 41,234 km.

In terms of logistic expense, the annual flows from the 2 DCs is estimated to cost Berlin Beer 2,492,103.65$. Of course, the summer period contributes a larger part of around 1.433 million, and the rest of 1.048 million is due to the Winter period.

In terms of cities, the shipping cost to Vienna (243,051$), Stockholm (225,614$), and Rome (168,453$) are listed as the three most expensive expenses. It should be noted that all these three cities are located near the Spain DC.

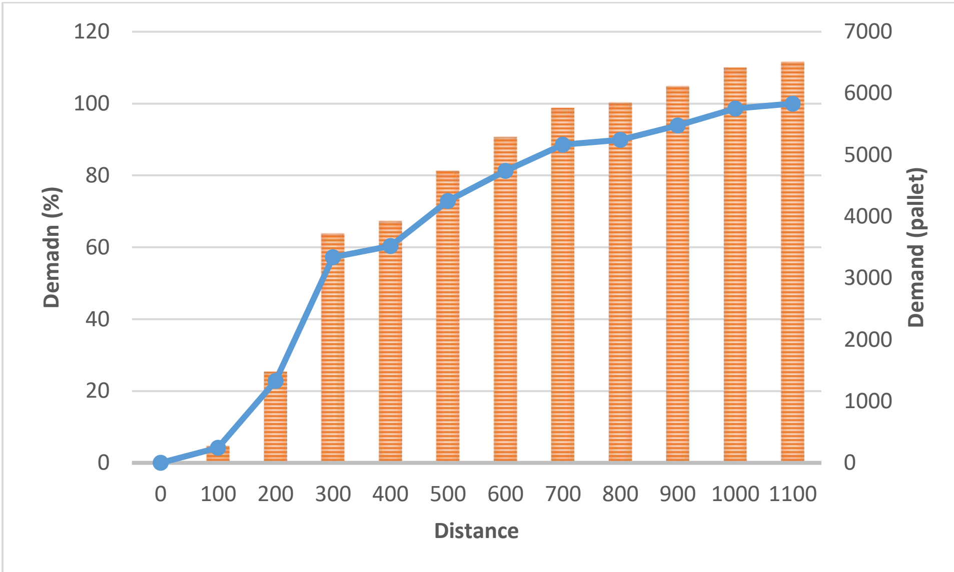

Figure 2-2: Demand coverage of 2 sites

The above figure depicts the demand coverage of the two DCs. Within the first 200 km radius, the Demand coverage rate is only about 23; However, as soon as the radius is expanded to 300 km, more than 60% of Demand is covered. However, it must be noted that the spread is very wide when there are customers up to 900 km away from 2 DCs.

2.1.2. 7 sites

The following graphic depicts the 7 DC locations that Berlin Beer intends to establish under this scenario. Evidently, a distinct regional partition is apparent. Three distribution centers (DCs) are established in Berlin, Cologne, and Munich, serving as key hubs in the primary market of Germany and central Europe. A new distribution center (DC) was created in Tidan, Sweden with the purpose of addressing the logistical challenges in the Nordic market. In the westernmost part of Europe, two data centers were constructed in Barcelona and Madrid, Spain. Italy has a single data center, which only caters to a solitary client located in Naples.

The estimated flows, distance to sites, and logistic cost are summarized in the table below:

Table 2-2: Estimated product flows of 7 DCs

City	Total			Summer period			Winter period		
	Flows	Distance	Cost estimation	Flows	Distance	Cost estimation	Flows	Distance	Cost estimation
Vienna	437.45	717.21	156,872.08	253.50	358.61	90,906.56	183.95	358.61	65,965.53
Hamburg	416.65	508.91	106,018.57	241.80	254.46	61,527.16	174.85	254.46	44,491.41
Paris	153.40	890.75	68,320.25	89.05	445.37	39,660.48	64.35	445.37	28,659.77
Stockholm	235.30	491.89	57,870.51	136.50	245.94	33,571.29	98.80	245.94	24,299.22
Milan	88.40	697.68	30,837.50	51.35	348.84	17,912.96	37.05	348.84	12,924.54
Frankfurt	169.65	357.01	30,283.06	98.15	178.50	17,520.08	71.50	178.50	12,762.97
Seville	74.10	783.28	29,020.39	42.90	391.64	16,801.28	31.20	391.64	12,219.11
Bremen	130.00	432.77	28,129.95	75.40	216.38	16,315.37	54.60	216.38	11,814.58
Stuttgart	144.30	380.07	27,422.35	83.85	190.04	15,934.61	60.45	190.04	11,487.74

City	Total			Summer period			Winter period		
	Flows	**Distance**	**Cost estimation**	**Flows**	**Distance**	**Cost estimation**	**Flows**	**Distance**	**Cost estimation**
Gothenburg	172.25	311.30	26,810.28	100.10	155.65	15,580.32	72.15	155.65	11,229.97
Turin	58.50	900.49	26,339.47	33.80	450.25	15,218.36	24.70	450.25	11,121.11
Malmö	35.10	673.34	11,817.14	20.15	336.67	6,783.91	14.95	336.67	5,033.23
Essen	135.85	25.63	1,741.23	78.65	12.82	1,008.08	57.20	12.82	733.15
Bochum	85.15	22.24	946.69	49.40	11.12	549.23	35.75	11.12	397.47
Berlin	820.30	0.38	155.96	475.80	0.19	90.46	344.50	0.19	65.50
Munich	338.00	0.61	103.38	196.30	0.31	60.04	141.70	0.31	43.34
Barcelona	171.60	0.25	21.82	99.45	0.13	12.65	72.15	0.13	9.17
Rome	189.15	0.07	6.93	109.85	0.04	4.02	79.30	0.04	2.90
Madrid	338.65	0.00	0.00	196.30	0.00	0.00	142.35	0.00	0.00
Grand Total	**6,509.10**	**20,143.06**	**986,839.65**	**3,762.85**	**10,071.53**	**570,743.70**	**2,746.25**	**10,071.53**	**416,095.95**

The establishment of 7 distribution centers (DCs) resulted in a considerable reduction in travel distance to 20,143 km, as compared to the product flows of just 2 DCs. Similarly, the expenses related to logistics have fallen by almost 50% to a total of $986,839.65. The Summer season accounts for about $570,743, while the Winter period accounts for the remaining $416,095.

Vienna, with a shipment cost of 156,872$, Hamburg, with a shipping cost of 106,018$, and Paris, with a shipping cost of 68,832$, are the three most costly cities in terms of shipping charges. Aside from Vienna, it is worth mentioning that the other two cities are situated in close proximity to each other in central Europe, which is the primary market for Berlin Beer. The high logistic cost may be attributed to the substantial beer consumption in these two locations, rather than showing an inefficiency in the supply chain design.

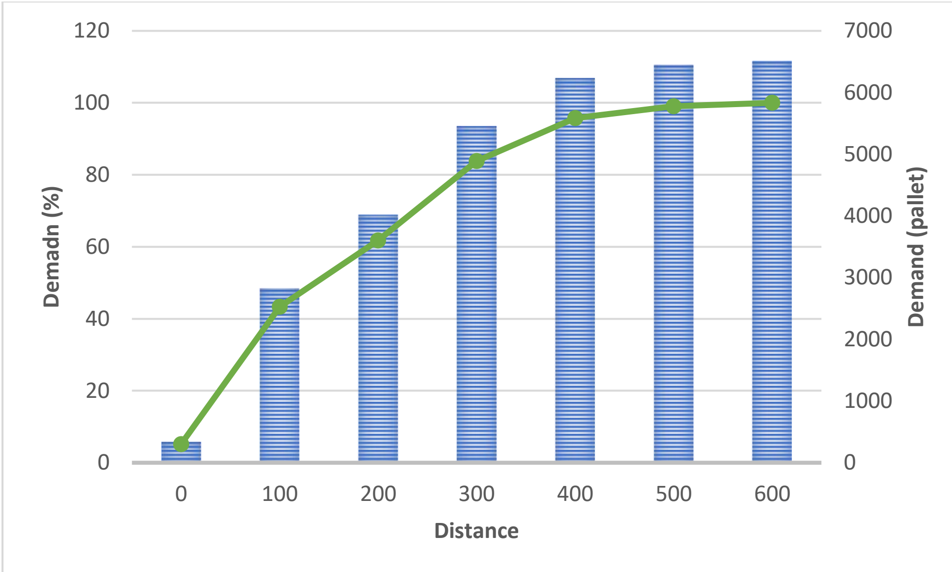

Figure 2-3: Demand coverage of 7 sites

The graphic above illustrates the extent to which the seven distribution centers meet the demand. Due to its extensive distribution network, Berline Beer's supply chain system efficiently fulfills over 40% of demand within a radius of 100 Km, thanks to its many distribution centers. The percentage steadily rises to 70% when the radius reaches 200 km, then grows further to 95% at a radius of 300 km. A fraction of the demand is situated within a radius of 400 km from the distribution centers. Nevertheless, the maximum distance is just 600 kilometers, in contrast to the 900 kilometers of the two distribution centers.

Table 2-3: Comparisons of two scenarios

	Distance (km)	Cost estimation ($)
7 sites	20,143.06	986,839.65
2 sites	41,234.82	2,492,103.65

In short, a distribution system with 7 DCs is likely to be more efficient than a distribution system with only 2 DCs.

2.2.Network optimization

Supply chain optimization involves fine-tuning the operational processes of a supply chain to maximize its efficiency. This optimization relies on certain key performance measures, such as total operational expenditures and the company's inventory returns (Liu et al. 2023). The objective is to provide clients with items at the most economical overall cost while maintaining the largest profit margins (Guo et al. 2022). In order to accomplish these objectives, managers must effectively manage the expenses associated with production, inventory control, transportation, and meeting consumer demands.

Given the intricacy of supply chain optimization, it is advisable to approach this business process as a long-term endeavor. An effective approach involves a combination of cost and service adjustments that are regularly evaluated to accommodate fluctuations in resource costs, carrier modifications, customer characteristics, and other variables necessitating ongoing scrutiny (Debuchi, Nishi, and Liu 2022; X. Wang et al. 2024). When a corporation is contemplating a merger or acquisition, or is focused on financial outcomes, the first course of action to investigate is supply chain optimization. A company conducting an inquiry may identify several factors contributing to the issue, such as exorbitant transportation expenses, suboptimal service standards, or discontent among service providers along the supply chain (Golmohammadi et al. 2024; Sharifi, Fang, and Amin 2023).

As the number of providers rises, expectations may shift or increase spontaneously. E-commerce enterprises have hastily adopted direct-sales capabilities in response to high market demand, without integrating them into other channels (Colajanni, Daniele, and Nagurney 2023). This method often results in increased expenses and disorganized administration. Supply chain optimization is crucial in establishing enhanced supply chain standards.

Supply chain network design is a systematic procedure that uses mathematical modeling to identify the optimal mix of facilities, suppliers, and goods. It is a purposeful strategy that circumvents the typical improvised expansion process seen in the majority of firms (Zhang et al. 2024). Prior to proceeding, it is essential to ascertain the commercial objectives of the corporation, including the specific markets being pursued, the intended expansion strategies, and the financial goals. Particular considerations include customer service standards, price, rivalry, and cash flow (Shirazaki, Pishvaee, and Sobati 2024). These procedures will decide the supply chain network to be followed, with the ultimate objective of identifying the most efficient mix of costs related to supply, manufacturing, and distribution. This is a methodical approach that eliminates subjectivity and prejudice.

The following figure presents the optimized network of Berlin Beer:

Figure 2-4: Optimized network

Table 2-4: Optimization results

# of Iteration	Flows	Profit	Profit per flows
Iteration 1: DC Berlin, Factory Berlin	1,490,534.00	12,277,202.35	8.24
Iteration 2: DC Berlin, Factory Berlin, DC Bochum	1,513,734.00	12,175,329.10	8.04
Iteration 3: DC Berlin, Factory Berlin, DC Austria	1,513,734.00	12,173,199.84	8.04
Iteration 4: DC Berlin, Factory Berlin, DC Italy	1,513,734.00	12,170,903.22	8.04
Iteration 5: DC Berlin, Factory Berlin, DC Spain	1,513,734.00	12,167,915.35	8.04
Iteration 6: DC Berlin, Factory Berlin, DC Switzerland	1,513,734.00	12,164,490.60	8.04
Iteration 7: DC Berlin, Factory Berlin, DC Sweden	1,513,734.00	12,134,673.43	8.02
Iteration 8: DC Berlin, Factory Berlin, DC Bochum, DC Austria	1,536,934.00	12,071,326.59	7.85
Iteration 9: DC Berlin, Factory Berlin, DC Italy, DC Bochum	1,536,934.00	12,069,029.97	7.85
Iteration 10: DC Berlin, Factory Berlin, DC Austria, DC Italy	1,536,934.00	12,066,900.71	7.85

In terms of finances, the first Iteration surpasses the others. This concise strategy involves a single distribution center (DC) and one plant located only in Berlin. Despite its simplicity, this plan yields an impressive profit of $12,277 million, with a relatively low flow of 1,490 million. As a result, it achieves a remarkable profit-to-flow ratio of 8.24, surpassing other alternatives. This is a logical conclusion given that the corporation mostly operates in Berlin, Germany.

Table 2-5: Flows details

Iteration	Flows	Distance	Travel time (days)	Flow cost, total	Cost per item
1	1,490,534.00	87,990.69	45.83	1,126,945.65	1.45
2	1,513,734.00	89,098.84	46.41	1,146,474.40	1.43
3	1,513,734.00	89,309.62	46.52	1,148,603.66	1.43
4	783,599.20	89,826.34	5.12	517,473.74	1.48
5	1,513,734.00	86,342.50	44.97	1,164,250.40	1.38
6	1,513,734.00	89,697.45	46.72	1,152,606.90	1.44
7	1,513,734.00	89,450.71	46.59	1,150,115.57	1.43
8	1,536,934.00	89,271.81	46.50	1,168,132.41	1.44
9	1,536,934.00	88,568.98	46.13	1,175,859.03	1.43
10	1,536,934.00	88,779.76	46.24	1,177,988.30	1.43

Option 5 offers the most cost-effective solution with the least overall transportation distance and duration. Thus, the individual cost of each item is the most economical at $1.38, despite the overall cost being quite expensive in comparison to other choices. The first option has the second lowest cost and the smallest total product flows. Additionally, it has the second lowest trip distance, after option 5. Nevertheless, considering a logistic cost of $1.45 per item, this choice ranks as the second most expensive, after option 4.

Table 2-6: Productions flows

Iteration	Beer	Crate	Hops	Malt
1	301,266.80	301,266.80	301,266.80	301,266.80
2	307,066.80	307,066.80	307,066.80	307,066.80
3	307,066.80	307,066.80	307,066.80	307,066.80
4	307,066.80	307,066.80	307,066.80	307,066.80
5	307,066.80	307,066.80	307,066.80	307,066.80
6	307,066.80	307,066.80	307,066.80	307,066.80
7	307,066.80	307,066.80	307,066.80	307,066.80
8	312,866.80	312,866.80	312,866.80	312,866.80

Iteration	Beer	Crate	Hops	Malt
9	312,866.80	312,866.80	312,866.80	312,866.80
10	312,866.80	312,866.80	312,866.80	312,866.80

Table 2-7: Revenue

City	Summer period	Winter period	Grand Total
Berlin	1,370,304.00	826,800.00	2,197,104.00
Vienna	730,080.00	441,480.00	1,171,560.00
Hamburg	696,384.00	419,640.00	1,116,024.00
Madrid	565,344.00	341,640.00	906,984.00
Munich	565,344.00	340,080.00	905,424.00
Cologne	413,712.00	249,600.00	663,312.00
Stockholm	393,120.00	237,120.00	630,240.00
Rome	316,368.00	190,320.00	506,688.00
Gothenburg	288,288.00	173,160.00	461,448.00
Barcelona	286,416.00	173,160.00	459,576.00
Frankfurt	282,672.00	171,600.00	454,272.00
Paris	256,464.00	154,440.00	410,904.00
Stuttgart	241,488.00	145,080.00	386,568.00
Düsseldorf	239,616.00	143,520.00	383,136.00
Dortmund	230,256.00	138,840.00	369,096.00
Essen	226,512.00	137,280.00	363,792.00
Bremen	217,152.00	131,040.00	348,192.00
Toulouse	54,288.00	32,760.00	87,048.00
Innsbruck	48,672.00	29,640.00	78,312.00
Bergen	46,800.00	28,080.00	74,880.00
Klagenfurt	39,312.00	23,400.00	62,712.00
Basel	35,568.00	21,840.00	57,408.00
Grand Total	**10,837,008.00**	**6,591,000.00**	**17,428,008.00**

Across all trials, Berlin regularly holds the top position in street markets, making the highest contribution to the company's revenue. Markets like as Vienna, Hamburg, Madrid, and Munich fall within the price range of around $1 million.

The optimization approach prioritizes the incorporation of flexibility into network architecture. Supply chain flexibility, which refers to the potential to readily modify production levels, procure raw materials, and adapt transport capacity, offers significant advantages over conventional supply chain management (J. Wang, Swartz, and Huang 2023). The conventional method of supply chain management is inflexible and lacks the ability to accommodate rapid modifications when necessary. These occurrences may lead to significant disruptions across the whole supply chain, whether it be due to sudden increases or decreases in demand or delays in the supply chain (Ala et al. 2024). The supply chain's ability to adapt to daily fluctuations is facilitated by its flexibility. Supply chain workers must use a platform that extracts valuable insights from extensive volumes of reliable data in order to overcome obstacles. By using scenario optimization, multi-echelon inventory (MEIO), and other sophisticated tools, supply chain planning becomes more flexible and allows immediate assessment of the overall effect of any change (Ryu et al. 2023).

2.3. Simulation

The following figure depicts the simulations in the operations of supply chain of Berlin Brewery from May 1 2021 to April 30 2022.

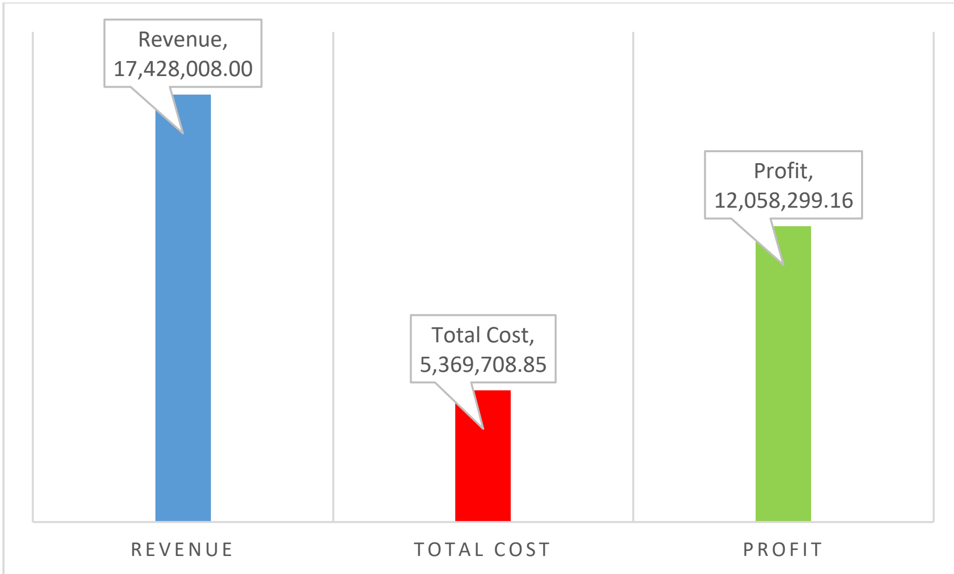

Figure 2-5: Simulated financial KPIs

When the supply chain runs smoothly, the company is expected to generate $12.06 million profit from $17.43 million of revenue. The graphic illustrates the service level for each product. The ELT Service Level by items indicates the proportion of items that are delivered on time compared to the total number of products that are sent. The product data is derived from the processed orders. Based on the visual representation, there is a huge difference in the pattern of service level by products between seasons (Summer and Winter). During the summer, this ration falls from 100% to around 94.6%; which perhaps suggests that rising demand overheats the supply chain and causes delay. During the Winter season, the demand is more stable, leading to a consistent increase in timely delivery. Hence, the service level increases.

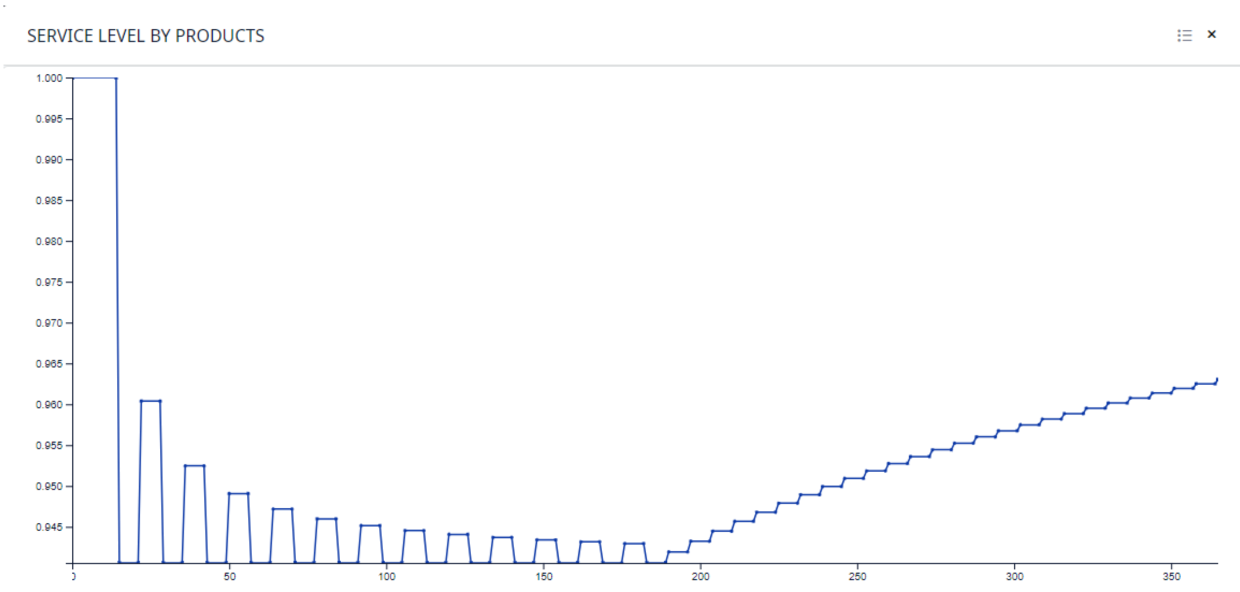

Figure 2-6: Simulated Service level by products

The "Available Inventory Including Backlog" provides information on the number of product items presently in stock, taking into account the quantity of processed goods for incomplete orders (orders that do not include the requisite amount of products).

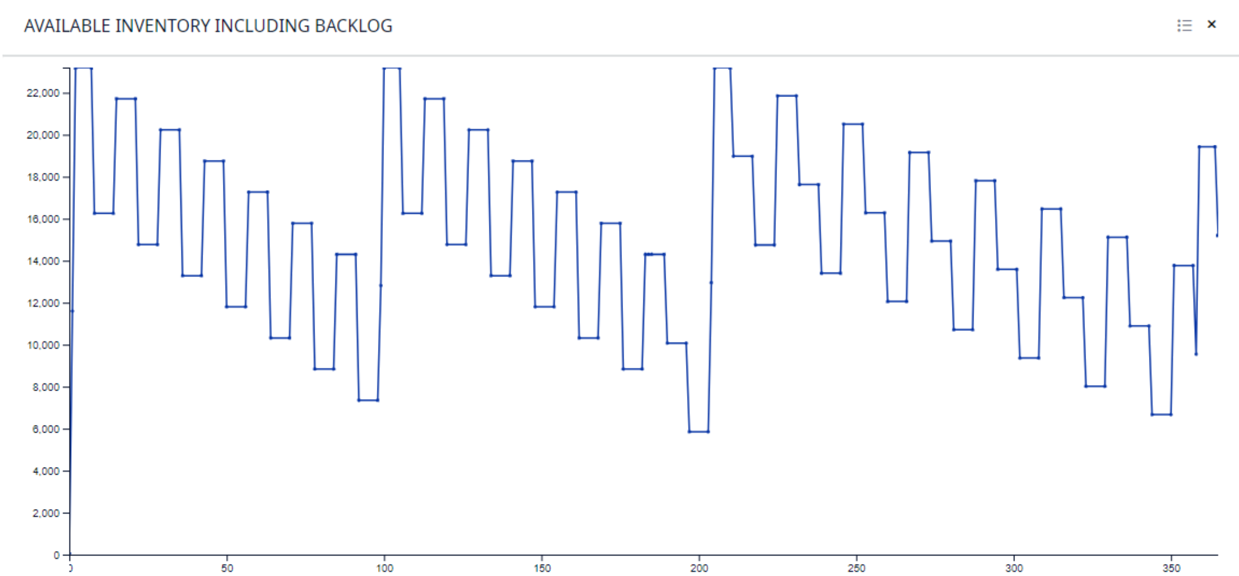

Figure 2-7: Simulated Available inventory including backlog

This index is also strongly influenced by the cyclicality of the brewery industry. Specifically, during the summer, stocks are often stored at a relatively large level and are replenished regularly. During the summer, a sales cycle lasts about 3 months (100 days). At the beginning, inventory will be stocked to approximately 22,000 pallets. Inventory will then be continuously distributed and replenished until it reaches 8,000 pallets. At this point, the company will restart the process and build inventory to 22,000 pallets. This sales cycle will be longer in the winter because demand is less than in the summer.

2.4. Risk analysis

2.4.1. Simulation 1

The following figure depicts the impacts of SC disruption on the supply chain of Berlin Brewery in the case only 1 DC is used.

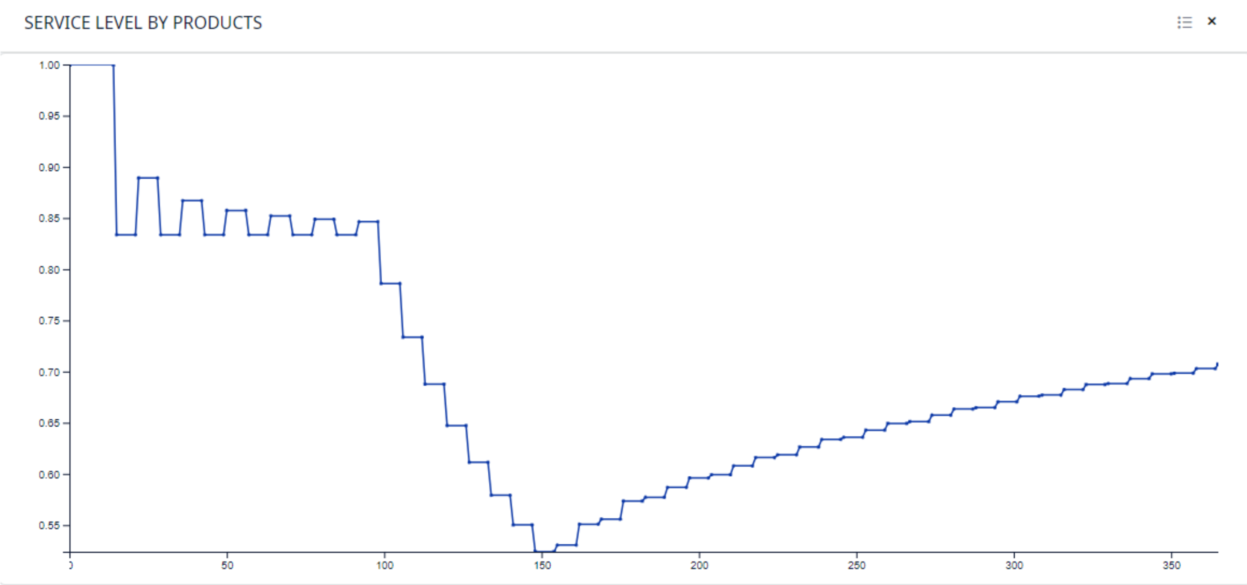

Figure 2-8: Simulated Service level by products in the event of 1 DC

Due to the presence of just one distribution center (DC) in operation, any improvement in the supply chain (SC) results in a significant decrease in the on-time delivery rate, plummeting from 85% to 50%. Following the occurrence of that event, the market had a subsequent boost, but it is now in a winter phase characterized by a significant decline in demand. Hence, it is challenging to reinstate the efficacy of the supply chain system.

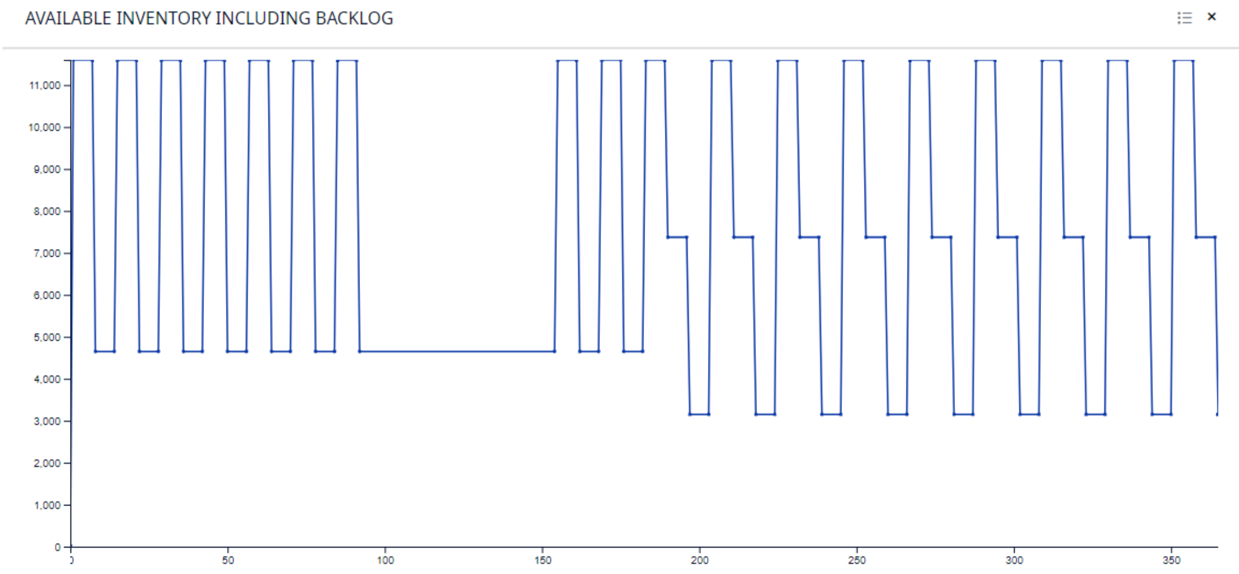

Figure 2-9: Simulated Available inventory including backlog in the event of 1 DC

The presence of just one data center amplifies the severity of interruptions since it hinders the company's sales cycle. Throughout the 2-month period of interruption, the available inventory was able to be maintained at a level of 5,000 units. Concurrently, there is a significant surge in demand throughout the summer months. Consequently, this disturbance in the supply chain has resulted in substantial financial losses for the organization.

2.4.2. Simulation 2

The following figure depicts the impacts of SC disruption on the supply chain of Berlin Brewery in the case only 2 DC is used.

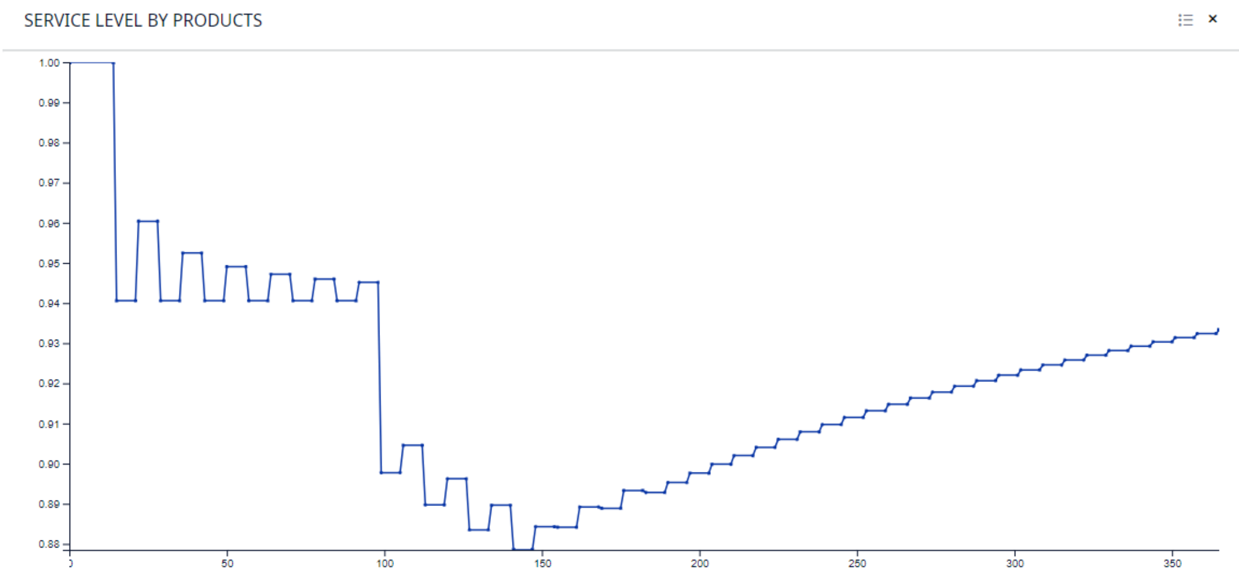

Figure 2-10: Simulated Service level by products in the event of 2 DC

In contrast to the previous simulation, the presence of 2 data centers has greatly mitigated the effects of interruptions. The service level by goods index reduced from 96% to 88%, however this decline is negligible compared to the effect of interruptions in scenario 1.

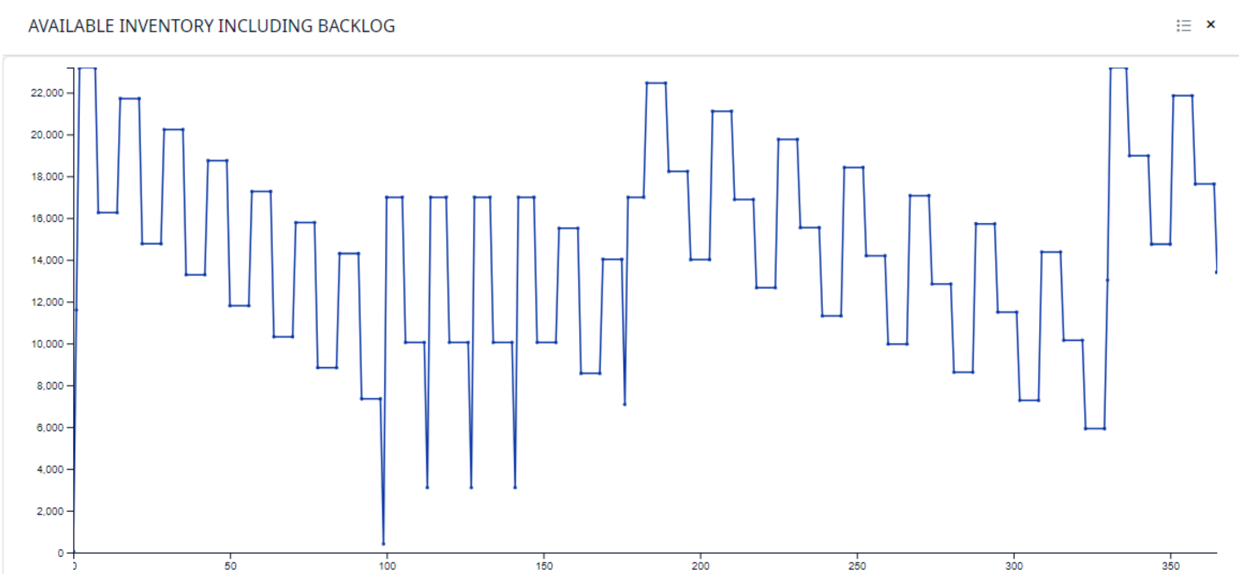

Figure 2-11: Simulated available inventory in the event of 2 DCs

The interruption has a lesser influence on the available inventory index. Despite certain instances when inventory levels were limited to 2,000 pallets, this phase of reorganization was brief. Berlin Brewery swiftly achieved the capability to consistently keep inventory levels at about 10,000-

12,000 pallets. This ensured that we effectively meet market demands and minimize the negative effects of interruptions on the company revenue.

The chart below compares the impact of SC disruptions on the company's financial KPIs.

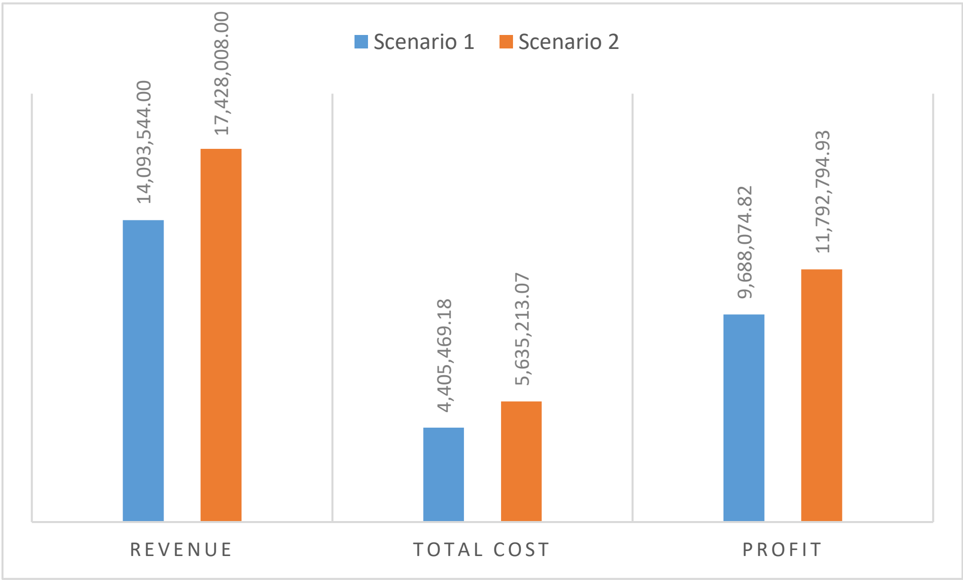

Figure 2-12: Comparison of financial KPIs between 2 scenarios

The advantage of scenario 2 becomes evident when considering its ability to generate a firm revenue of $17.48 million, surpassing the $14.09 million generated in scenario 1. The understanding of this is facilitated by the fact that in scenario 2, the system is equipped with two distribution centers (DCs) to consistently meet market demands. Consequently, the impact on income is not significant. Therefore, despite the increased expenses, scenario 2 yields a greater profit for the corporation compared to scenario 1 ($1.79 million against $9.69 million).

2.5. Comparison experiment

Table 2-8: Comparison of 3 scenarios

Scenario	**Service Level by Products**	**Available Inventory Including Backlog**	**Total Cost**	**Profit**
BR SIM Disruption Risk 1 DC	0.707	203.750	4,405,469.18	9,688,074.82
BR SIM Disruption Risk 2 DC	0.933	460.075	5,635,213.07	11,792,794.93
BR SIM	0.963	504.975	5,369,708.85	12,058,299.16

Undoubtedly, in optimal circumstances, we will choose BR SIM. Nevertheless, in the event of potential hazards, a supply chain equipped with two distribution hubs will provide enhanced safety measures. This is shown by the excellence in terms of punctuality in delivery and profitability rates.

2.6. Validation using variation

Table 2-9: Sensitive analysis

Iteration	Service Level by Products	Inventory Carrying Cost	Profit	Available Inventory	Total Cost	Transportation Cost
min: 900	0.9630	29,897.61	12,199,354.64	291.70	5,228,653.36	417,693.43
min: 1,100	0.9630	29,897.61	12,199,354.64	291.70	5,228,653.36	417,693.43
min: 1,300	0.9630	29,919.43	12,214,160.39	269.25	5,213,847.61	414,015.63
min: 1,500	0.9630	29,926.23	12,051,179.39	258.03	5,376,828.61	454,471.39
min: 1,700	0.9630	29,926.23	12,051,179.39	258.03	5,376,828.61	454,471.39
min: 1,900	0.9630	30,255.12	12,065,548.99	493.75	5,362,459.01	450,793.59
min: 2,100	0.9630	30,548.86	12,080,082.82	471.30	5,347,925.18	447,115.80
min: 2,300	0.9630	30,682.80	12,087,362.67	460.08	5,340,645.34	445,276.90

The table above presents a comprehensive examination of how changes in the Inventory policy affect the Key Performance Indicators (KPIs). Although the service level by goods ratio stays constant, the other four indicators are all more or less impacted. Specifically, modifying the inventory policy directly affects the available inventory index, which rises from 291 to 460. Simultaneously, there is a marginal rise in inventory and transportation expenses, which leads to little impact on profit when altering this parameter.

3. Managerial recommendations

Drawing from the above analysis, the author suggests a development of the 7 DC sites supply chain. Due to its extensive distribution network, Berline Beer's supply chain system efficiently fulfills over 40% of demand within a radius of 100 Km, thanks to its many distribution centers. The percentage steadily rises to 70% when the radius reaches 200 km, then grows further to 95% at a radius of 300 km. A fraction of the demand is situated within a radius of 400 km from the distribution centers. Nevertheless, the maximum distance is just 600 kilometers, in contrast to the 900 kilometers of the two distribution centers. From financial perspective, the 7-sites SC is twice cheaper as 2-sites plan. In addition, this extensive SC also adds intangible value of the future business success of the company such as:

- Cost reduction - GFA facilitates cost reduction in the supply chain by decreasing transportation expenses, reducing inventory holding costs, and improving facility use.
- Enhanced customer experience - Optimizing facility locations leads to improved levels of customer service (Li et al. 2024)**. By considering criteria such as location, lead periods, and order fulfillment capabilities, GFA may enhance the efficiency of order cycles and reduce product delivery times** (Dedoulis 2006)**.**
- Risk mitigation - GFA will include risk variables such as natural catastrophes, climate change, and political instability. By assisting the supply chain manager in identifying suitable locations for facilities in regions with less danger, the supply chain manager may effectively reduce the likelihood of encountering these situations (Reinstein and Reckers 2022)**.**
- Sustainable supply chains include optimizing the allocation of distribution centers and transit routes to increase sustainability efforts. This leads to a reduction in carbon emissions and promotes eco-friendly operations (Walker 2023)**.**
- Enhanced cognitive processes leading to improved decision-making. By using data-driven supply chain insights, GFA assesses various situations to assist managers in making well-informed choices that are in line with company goals (Guo et al. 2022)**.**

In terms of network optimization, the first Iteration surpasses the others. This concise strategy involves a single distribution center (DC) and one plant located only in Berlin. Despite its simplicity, this plan yields an impressive profit of $12,277 million, with a relatively low flow of 1,490 million. As a result, it achieves a remarkable profit-to-flow ratio of 8.24, surpassing other alternatives. This is a logical conclusion given that the corporation mostly operates in Berlin, Germany. Option 5 offers the most cost-effective solution with the least overall transportation distance and duration. Thus, the individual cost of each item is the most economical at $1.38, despite the overall cost being quite expensive in comparison to other choices. The first option has the second lowest cost and the smallest total product flow. Additionally, it has the second lowest trip distance, after option 5. Nevertheless, considering a logistic cost of $1.45 per item, this choice ranks as the second most expensive, after option 4.

As the network is optimized, Berlin Beer might receive countless benefits such as:

- **Cost Reductions**

Supply chain optimization may effectively remove superfluous expenditures, therefore optimizing the financial aspects of corporate operations (Nishi et al. 2020). Any procedures that are repetitive or ineffective may be abolished or automated as necessary. The primary emphasis may be shifted towards satisfying client requirements via punctual and precise delivery. Implementing supply chain cost optimization enables a firm to reduce its inventory levels, so freeing up capital and mitigating the risk of product obsolescence (Gao et al. 2024). Furthermore, the costs associated with supply chain infrastructure may be more effectively controlled by improving delivery methods, logistics, and storage capacities.

- **Increased Revenues and Profits**

Supply chain optimization tools provide managers with a comprehensive understanding of all operations, enabling them to enhance the efficiency of supply chain processes. The customer is expected to have a higher level of commitment to the process and is likely to have enhanced experience (Nishi et al. 2020). The organization ensures precise and punctual delivery of orders, while also enhancing its responsiveness to consumer needs. The outcome is a shortened investment-to-return-on-investment cycle and prompt resolution of bills, which fosters customer loyalty.

- **Better Supplier Performance**

Implementing digital technology in the supply chain allows for immediate access to up-to-date information and analysis of the supply chain. The evaluation of suppliers' performance allows for targeted improvements and appropriate recognition of exceptional performance. It establishes the groundwork for an ongoing process of enhancing supplier performance, which is crucial for making strategic sourcing choices (Ahmadi-Javid and Hoseinpour 2015). The organizational ecosystem includes suppliers, partners, vendors, and all the interconnected interfaces associated with them. By consolidating these businesses into a unified supply chain optimization system, it facilitates enhanced cooperation and innovation (Bilgen and Ozkarahan 2004). Each stakeholder has the ability to retrieve current information, and by working together as a unified team, they can make more informed business choices, therefore promoting improved supply chain continuity and mitigating potential risks.

- **Quality management**

Quality management in a supply chain encompasses the whole manufacturing process, starting with the acquisition of raw materials to the final delivery of the product. Supply chain optimization approaches enable firms to enhance efficiency and minimize waste by ensuring quality at every level. These methodologies further create a basis for facilitating the optimization of supply chain planning, guaranteeing adherence to defined quality standards throughout each phase of the process.

From a risk analysis perspective, it is recommended that a supply chain with diversification is superior. Unlike the previous simulation, the existence of 2 data centers has significantly reduced the impact of outages. The service level, as measured by the goods index, decreased from 96% to 88%. However, this loss is insignificant when compared to the impact of disruptions in scenario 1. The disruption has a reduced impact on the available inventory index. Although there were some cases when inventory levels were restricted to 2,000 pallets, this phase of restructuring was short-lived. The Berlin Brewery quickly developed the capacity to continuously maintain inventory levels of about 10,000-12,000 pallets. This provided optimal responsiveness to market needs and mitigated the adverse impact of disruptions on corporate income. Scenario 2 has an edge in terms of its capacity to create a substantial revenue of $17.48 million, which exceeds the $14.09 million generated in scenario 1. The comprehension of this is aided by the fact that in scenario 2, the system is furnished with two distribution centers (DCs) to continually fulfill market wants. Hence, the effect on revenue is negligible. Consequently, despite the higher costs, scenario 2 generates a larger profit for the company in comparison to scenario 1 ($1.79 million vs $9.69 million).

Last but not least, it is essential to adopt sensitive analysis excessively in the process of supply chain management. Sensitivity analysis is a useful tool for optimizing many components of the supply chain, including inventory management, production planning, and transportation (Sheibani and Niroomand 2024; Che 2017). For instance, a corporation may do sensitivity analysis to determine the most favorable inventory levels that will save expenses while guaranteeing sufficient stock quantities to satisfy client demand. Moreover, sensitivity analysis may be used to enhance production planning by discerning the repercussions of alterations in production schedules on costs and performance.

When improving supply chain management, many elements need to be considered. Sensitivity analysis is a key aspect that significantly influences this procedure. Sensitivity analysis is a statistical method used to determine the impact of changes in one or more variables on the final result (Che 2017). Sensitivity analysis, within the realm of supply chain optimization, aids in identifying the most influential factors within the supply chain and determining how adjustments to these variables might enhance overall efficiency.

Sensitivity analysis is crucial for supply chain management from a financial standpoint. Through the analysis of various scenarios, firms may discern possible risks and opportunities that may impact their financial performance. For instance, a corporation may do sensitivity analysis to ascertain the influence of fluctuations in demand or supply on its inventory levels. Through this approach, businesses may manage their inventory levels to guarantee sufficient stock availability to fulfill demand, while also avoiding the expensive consequences of overstocking.

Sensitivity analysis, from an operational standpoint, may also assist in the identification of possible bottlenecks or inefficiencies within the supply chain. Through the analysis of various scenarios, companies may identify areas where delays or disruptions are probable and implement measures to alleviate these risks. For instance, a corporation can use sensitivity analysis to assess the repercussions of alterations in transportation routes or delivery durations on their total logistics operations. By engaging in this practice, they may discern possible complications and adapt their operations appropriately to mitigate the repercussions on their supply chain.

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