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Production Location Selecting and Subsequent Production Decision Making for Sport Obermeyer

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Abstract: This paper revolved around two core research issues: production location selection and subsequent production decisions. The aim of the study was to provide a detailed analysis of Sport Obermeyer's data from 1992 to 1995 in a new way, hoping to assist companies facing similar challenges. The paper took Cost, Quality, Lead time and Minimum order quantity as bridges to the four main factors affecting the choice of production location. It detailed the advantages and disadvantages of the two production locations: Hong Kong and China. Then, with the aid of the Newsvendor model, the mismatch cost ratio for the 10 styles was determined. Ultimately, using the coefficient of variance for comparison and confirmation of the mismatch cost ratio results, the paper helped Sport Obermeyer analyze which styles of parkas had low-risk and low-uncertainty demand, and which had high-risk and high-uncertainty. The paper then combined the characteristics of the two production locations and assisted Sport Obermeyer in making subsequent production decisions. Five styles of parkas suitable for production in China and five styles suitable for production in Hong Kong were identified, ensuring stable profits and deliveries for Sport Obermeyer.

Keywords: Production location, mismatch cost ratio, newsvendor model

1. Introduction

The snow-capped peaks of Aspen, Colorado, aren't just home to skiers and snowboarders eager to carve fresh tracks. They were also the birthplace of Sport Obermeyer, a trailblazing skiwear company founded in 1947 by Klaus Obermeyer. During the 1990s, globalization has unlocked doors to a multitude of manufacturing landscapes. As companies grapple with the question of where to produce, quality, cost, and speed become the critical trifecta guiding decisions. As for Sport Obermeyer, the challenge was even greater. The nature of fashion, combined with the unpredictability of weather patterns, meant that demand was incredibly hard to forecast. Produce too much, and you risk unsold inventory. Produce too little, and you miss out on potential sales. The stakes were high, and a misstep could cost the company its reputation and revenue. The way to navigate this intricate dance of supply and demand. The way to choose their production locations amidst a plethora of options, and to make the crucial subsequent production decisions that ensured products were on the shelves just when consumers wanted them.

Having posed these critical research questions, it becomes essential to contextualize them within the broader scholarly discourse. The decision-making process around production location selection and subsequent operational choices has long intrigued researchers, strategists, and business leaders

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alike. To understand the nuances and underpinnings of these decisions, people must delve into the existing body of literature that has shaped current perspectives and practices. There are many researchers who have analyzed many cases or have adopted new algorithms or decision-making methods to determine the selection of production sites or make subsequent production decisions. Darvish and Coelho analyzed a system that encompasses both production and distribution and suggested a series of step-by-step methods and a metaheuristic to compare solution costs obtained from their two methods [1]. Ketokivi and Turkulainen conducted a thorough analysis of 35 decisions regarding the location of final assembly by investigating the crucial connections among production, supply chain, product development and market. This was done to comprehend the factors influencing the selection of a manufacturing site from both strategic and economic policy viewpoints, particularly in a setting characterized by high GDP per capita [2]. Buciuni and Finotto analyzed through multiple case studies, focusing on the continuity between the development activities of production sites and production and found that the implementation of a specific set of development tasks relies on specialized knowledge in manufacturing, which is central to the judgment of production location selection [3]. Shahabi and Tafreshian investigated the challenge associated with production, inventory, and location with interrelated demand and devised an approach relying on the external estimation of the non-linear components to tackle the issue [4]. Yu and Normasari proposed a comprehensive strategy for designing the supply chain network and developed a mathematical model geared towards minimizing the overall cost of the supply chain, emphasizing the selection of suitable locations for new plants and distribution centers, while determining the production and distribution of the product [5, 6]. Bhatnagar and Lin applied a Markov decision process model to the transshipment issue and defined the desirable strategy for a two-location scenario and lost-sales model [7, 8]. Shafiee-Gol and Kia formulated a mixed-integer nonlinear programming model to deal with the location-distribution and production planning issues, across multiple plants under dynamic conditions [9, 10]. Sharkey and Geunes presented exact branch-and-price algorithms for a category of facility location issues with a temporal dimension and several key variations [11].

Many researchers have also proposed new conditions for investigating production location. Fuchs highlighted the importance of location-specific variations in production attributes and in consumer demand for technological competitiveness [6]. Some researchers have even proposed new production site options and production methods that are responsive to the times. Treber and Moser proposed a methodology that is practical and application-oriented for redistributing production technologies across manufacturing locations in worldwide production networks [8].

Motivated by a real case, this paper will go back to 1992-1995 with the help of Sport Obermeyer's data at the time to use an innovative method with a focus on combining traditional analysis with innovative metrics such as mismatch cost ratio and coefficient of variation to provide a novel, multidimensional approach to problems of production location selection and following production decisions, offering a blueprint for effective supply chain management to unearth invaluable insights on balancing demand-supply dynamics, choosing optimal production locations, and predicting market needs.

2. Methods

2.1. Data Source

The data for this literature are collected from the Sport Obermeyer website, which is provided by actual operations of Sport Obermeyer, and from the classic case study of the Sport Obermeyer. All data are from 1992 to 1995.

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2.2. Variable Selection

The data utilized for this paper mainly consists of two parts. The first part (see Table 1 below) includes five variables (Styles, Price, Name of people who participate in forecasts, Average Forecasts, Twice the Standard deviation). The second part (see Table 2 below) includes 12 variables (Production Location, Wage per hour, Exchange Rate, Hours Worked, Weekly Output per worker, Actual Work Effort per parka, Compensated Work Duration per parka, Cost of Labor per parka, Production Line, Training, Repair Rate, Minimum Order Quantity).

Table 1: Committee's Forecasts.

Style	Price	Laura	Carolyn	Greg	Wendy	Tom	Wally	μ
Gail	$110	900	1000	900	1300	800	1200	1017
Isis	$99	800	700	1000	1600	950	1200	1042
Entice	$80	1200	1600	1500	1550	950	1350	1358
Assault	$90	2500	1900	2700	2450	2800	2800	2525
Teri	$123	800	900	1000	1100	950	1850	1100
Electra	$173	2500	1900	1900	2800	1800	2000	2150
Stephanie	$133	600	900	1000	1100	950	2125	1113
Seduced	$73	4600	4300	3900	4000	4300	3000	4017
Anita	$93	4400	3300	3500	1500	4200	2875	3296
Daphne	$148	1700	3500	2600	2600	2300	1600	2383
Totals	-	20000	20000	20000	20000	20000	20000	20000

The reason only five people participated in Forecast is that in 1992, Wally Obermeyer, the Vice president of the Sport, modified the company's standard procedure where the committee would make production commitments based on the collective agreement of the group. Instead, in an effort to obtain more comprehensive data, Wally instructed each committee member to independently project the retailer demand for every Sport Obermeyer product, as indicated in Table 1.

Table 2: Comparison of operations between Hong Kong and China.

Topic	Hong Kong	China
Exchange Rate	HK$7.8 = US$1	RMB 5.7 = US$1
Wage per hour	HK$30	RMB 0.91
Hours Worked	48 hours per week	58.5 hours per week
Weekly Output per worker	19 parkas	12 parkas
Actual Work Effort/parka	~2.36 hours	~3.7 hours
Compensated work duration per parka	~2.54 hours/parka	~4.89 hours/parka
Cost of Labor per parka	HK$75.7	RMB4.46
Training	Trained in multiple areas	Trained for single task
Minimum Order Quantity	600 units	1200 units
Repair Rate	1-2 %	~10 %
Production Line	10-13 people/line	40 people/line

Table 1 showed the 10 styles of Women's Parkas and the six committee members' predictions of the demand for these 10 styles of Women's Parkas. Considering the Balance Between Precision and Reliability, this paper chooses to use Twice the standard deviation, which is 95% confidence interval.

Because all data are from 1992-1995, before Hong Kong was returned to China, China is used here instead of mainland. Table 2 showed the specific comparison between two production locations (Hong Kong and China) from 1992 to 1995.

2.3. Research Protocol

This paper will use the Newsvendor Model combined with Normal Demand Distribution to find the quantity of maximum profit. Combined with Loss Function, Expected sales and Expected leftover inventory, Expected profit can be obtained, and mismatch cost ratio can be obtained by combining maximum profit. Finally, combined with the coefficient of variance for double check and comparison, the subsequent production decision was obtained.

3. Results and Discussion

3.1. Comparison of Two Production Locations

Figure 1 showed the four main factors affecting the selection of production locations. Because the data were from 1992-1995, China was used here instead of Mainland.

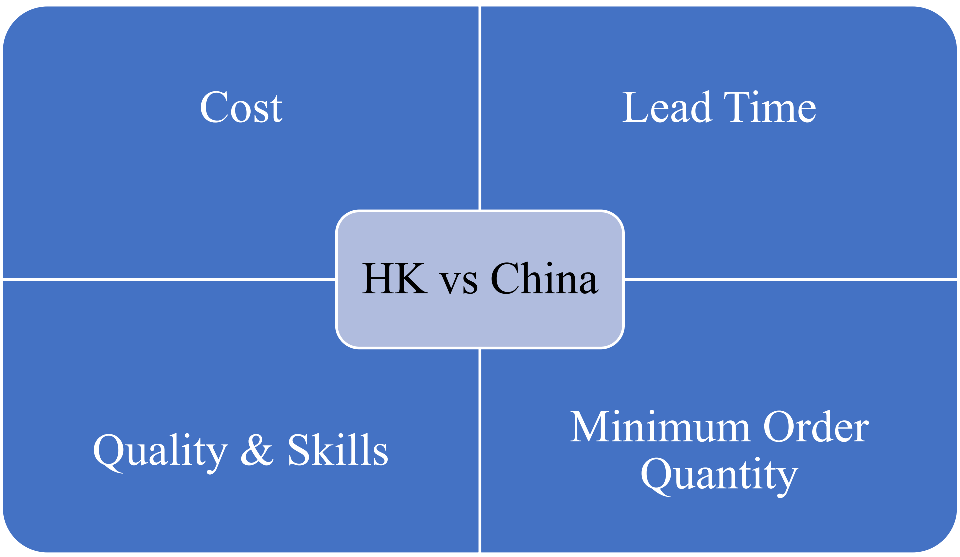

Figure 1: Main factors of comparison.

First, regarding Quality & Skills, at the time of the case, the training for Hong Kong workers and Chinese mainland workers was completely different. Workers in Hong Kong were usually trained in multiple areas, encompassing a wider variety of responsibilities. In contrast, Chinese mainland workers were trained for single operations only. On average, Hong Kong workers operated approximately 50% more efficiently than workers in China and offered greater flexibility in production. Additionally, since Hong Kong workers generally had higher technology proficiency and better repair rate control than Chinese mainland workers (1-2% vs. ~10%), the quality of the products produced was generally superior. In conclusion, Hong Kong was perceived to possess a skilled workforce and superior quality control.

Second, concerning Lead Time, lead time, within a supply chain context, refers to the duration between placing an order (or initiating production) and when the finished goods are ready for shipment or delivery. Hence, lead time and productivity are intrinsically linked (assuming all other external factors remain constant). By comparing the productivity of workers in Hong Kong with those in the Chinese mainland from 1992 to 1995, it's evident that due to the higher skill proficiency of the

Hong Kong workers-evidenced by weekly output per worker (19 parkas vs 12 parkas) and actual work effort per parka (~2.36 hours vs ~3.7 hours)-Hong Kong workers held a clear advantage. Furthermore, China had longer production lines (40 people/line vs 10-13 people/line). A longer production line typically translates to a longer duration to complete a product. This increases the overall lead time. The prolonged lead time in China implies that production decisions must be made well in advance, with less demand information available. This situation makes China less suitable for items with unpredictable demand.

Third, concerning cost, Table 2 and Figure 1 reveal that the wages for Hong Kong workers (HK$30) were higher than those of Chinese mainland workers (RMB 0.91). Moreover, the cost of labor for each parka was notably greater for Hong Kong workers (HK $75.7) compared to Chinese workers (RMB 4.46). Since both regions paid workers on a piece-rate basis, Chinese workers generally earned lower wages and incurred lower overtime costs. Thus, in terms of cost, China held an advantage over Hong Kong. The elevated production costs in HK suggested that producing large quantities there wasn't economical. Conversely, lower production costs made China the ideal location for bulk production. For items with high uncertainty, the trade-off between cost and the ability to respond swiftly to changing demand justified production in HK. For predictably demanded items, China offered significant cost savings for Obermeyer.

Fourth, regarding the minimum order quantity, Hong Kong had a lower threshold (600 units of the same style vs 1200 units of the same style). This was advantageous for high-risk items, as Obermeyer might not have wanted to commit to vast quantities without a clearer demand forecast. China, with its higher minimum order quantities, was less suitable for speculative items but was more fitting for items with stable demand.

In conclusion, with its flexibility, shorter lead time, and skilled labor, Hong Kong was ideal for items with uncertain and high-risk demand. In contrast, China, with its cost-efficiency, large-scale production capability, and extended lead time, emerged as the preferred choice for items with predictable and low-risk demand.

3.2. Making Following Production Decision

Due to uncertain demand, a single period, and other conditions, the paper initially used the Newsvendor Model to determine the probability that demand would be less than or equal to a specific quantity. This was done because profit is maximized in this scenario, leading to the identification of the critical ratio.

$$\text{Critical Ratio} = \frac{\text{Cu}}{\text{Cu}+Co} = \frac{\$27}{\$27+\$9} = 0.75, \quad (1)$$

where Cu is underage cost, Co is the overage cost According to the Central Limit Theorem, this paper assumed a normal distribution and used the inverse normal to determine the z-score (0.6745) corresponding to the percentile of the critical ratio. Using the z-score formula, the paper calculated the corresponding x, which yielded the quantity for maximum profit.

$$z = \frac{\text{x}-\mu}{\sigma} \quad (2)$$

Table 3 showed the calculation process of maximum profit of these 10 styles of parkas. The next step is to calculate the mismatch cost ratio to determine which products are high uncertainty (high risk) and which products are low uncertainty (low risk). In order to find the mismatch cost ratio, this paper need to first find the Expected sales and Expected leftover to find the Expected profit.

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Table 3: Max-profit quantity.

Style	Average Forecasts	Standard Deviation	Max-profit Quantity
Gail	1017	388	1278.702
Isis	1042	646	1477.72
Entice	1358	496	1692.547
Assault	2525	680	2983.653
Teri	1100	762	1613.961
Electra	2150	807	2694.313
Stephanie	1113	1048	1819.865
Seduced	4017	1113	4767.707
Anita	3296	2094	4708.382
Daphne	2383	1394	3323.239
Totals	-	-	26360.089

$$Expected\ profit = (\text{Price} - \text{Cost}) \times \text{sales} - (\text{Cost} - \text{Salvage value}) \times \text{leftover} \quad (3)$$

$$Expected\ sales = \text{Expected (Mean)}\ demand - Expected\ shortage \quad (4)$$

$$Expected\ shortage = \text{L(z)} \times Standard\ deviation \quad (5)$$

$$Expected\ leftover = \text{Quantity} - \text{Expected sales} \quad (6)$$

Table 4 showed the calculation process of the Expected profit of these 10 styles of parkas by calculating Expected sales, Expected shortage and Expected leftover.

Table 4: Expected profit.

Style	Expected shortage	Expected sales	Expected leftover	Expected profit
Gail	57.8896	959.1104	319.5916	244.08
Isis	96.3832	945.6168	532.1036	250.08
Entice	74.0032	1283.997	408.5501	325.92
Assault	101.456	2423.544	560.1090	606
Teri	113.6904	986.3096	627.6516	264
Electra	120.4044	2029.596	664.7176	516
Stephanie	156.3616	956.6384	863.2269	267.12
Seduced	166.0596	3850.940	916.7667	964.08
Anita	312.4248	2983.575	1724.806	791.04
Daphne	207.9848	2715.015	1148.224	571.92

To obtain the Expected Shortage, L(z), the loss function, is needed. This paper obtained L(z) (0.1492) using the following function:

$$NORMDIST(z,0,1,0) - \text{z} \times (1 - \text{NORMDIST(z,0,1,1)}) \quad (7)$$

Then, this paper will find the maximum profit, and combine with quantity to find the mismatch cost ratio corresponding to these 10 styles.

$$Maximum\ profit = (\text{Price} - \text{Cost}) \times \mu \quad (8)$$

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$$Mismatch\ cost = Maximum\ Profit - Expected\ Profit \tag{9}$$

$$Mismatch\ ratio = Mismatch\ cost\ \div Quantity \tag{10}$$

Table 5: Mismatch cost ratio.

Style	Expected demand	Maximum profit	Mismatch Cost	Mismatch Cost Ratio
Gail	1017	244.08	39.4608	0.03880121
Isis	1042	250.08	65.7003	0.06305207
Entice	1358	325.92	50.4448	0.03714638
Assault	2525	606	69.1582	0.02738937
Teri	1100	264	77.4978	0.07045257
Electra	2150	516	82.0745	0.03817417
Stephanie	1113	267.12	106.5849	0.09576364
Seduced	4017	964.08	113.1956	0.02817915
Anita	3296	791.04	212.9665	0.06461361
Daphne	2383	571.92	141.7742	0.05949401

Table 5 showed the calculation process of mismatch cost ratio of these 10 styles of parkas. According to the Table 5, this paper took mismatch cost ratio = 0.05 as the boundary. Mismatch cost ratios higher than 0.05 were considered high risk and high uncertainty, while those lower than 0.05 were deemed low risk and low uncertainty. This paper then performed the alignment using the coefficient of variance. The coefficient of variance provided a relative measure of variability with respect to the mean. A higher coefficient of variance indicated greater variability, which could be interpreted as higher uncertainty in demand. In the context of cloth production, it offered an understanding of how stable or predictable the demand was for a particular product. By combining the two, products with a high coefficient of variance and high mismatch cost ratio were the riskiest. They had uncertain demand, and any forecasting error could have been costly.

$$Coefficient\ of\ Variance = \left(\frac{\text{Standard deviation}}{\text{Mean}} * 100\right)\% \tag{11}$$

Table 6: Coefficient of variance and mismatch cost ratio.

Style	Standard deviation	Coefficient of Variance	Mismatch Cost Ratio
Gail	388	0.3815	0.0388
Isis	646	0.6199	0.0630
Entice	496	0.3652	0.0371
Assault	680	0.2693	0.0273
Teri	762	0.6927	0.0704
Electra	807	0.3753	0.0381
Stephanie	1048	0.9415	0.0957
Seduced	1113	0.2770	0.0281
Anita	2094	0.6353	0.0646
Daphne	1394	0.5849	0.0594

Table 6 compared and confirmed the coefficient of the variance and the mismatch cost ratio of the demand of these 10 styles of parkas. As could be seen from the Table 6, the five styles with a

Mismatch cost ratio lower than 0.05 were also the five styles with a lower Coefficient of Variance. Therefore, when combined with the characteristics of the two production locations of Hong Kong and China, this paper placed these five styles with low Mismatch cost ratio and Coefficient of variance (Gail, Entice, Assault, Electra, Seduced) in China for production. This paper assigned the other five styles (Isis, Teri, Stephanie, Anita, Daphne) with high Mismatch cost ratio and Coefficient of variance to Hong Kong for production.

4. Conclusion

In conclusion, by analyzing and comparing Hong Kong and China from the perspectives of cost, lead time, quality, and minimum order quantity, this paper concluded that Hong Kong, with its better flexibility and shorter lead time, was more suitable for production with high risk and high uncertainty demand. On the other hand, China, benefiting from lower costs and larger minimum order quantities, was more suitable for production with low risk and low uncertainty demand. Using the Newsvendor model, the mismatch cost ratio and coefficient of variance were compared and verified, with a mismatch cost ratio of 0.05 set as the boundary. Ultimately, 5 styles suitable for production in China and 5 styles suitable for production in Hong Kong were identified. As algorithms continue to progress, there will be increasingly efficient ways to assist enterprises in making production decisions in the future.

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