Logistics & Supply Chain

Sport Obermeyer Case Study

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Executive Summary

After half a century in the industry, Sport Obermeyer, a leading winter sports apparel company, faces challenges in streamlining production efficiency and deciding between sewing and cutting suppliers in China and Hong Kong for 1993 and beyond.

As an immediate concern, a decision must be made about the first production order of the 1993-94 production line for a subset of ten parka style, accounting for 10% of the company's demand. A significant challenge that stresses the decision-making landscape is the temporal misalignment between the company's demand patterns and the timing of events. Specifically, 80% of the retailers orders (demand) materializes post the Las Vegas show, yet the initial production order must be placed before this crucial event. The analysis focuses on optimizing production quantities while considering normal distribution of demand, demand uncertainty, profit margins, and production constraints.

The approach taken is to define an optimization problem that maximizes utility. The objective function combines profit per sold unit, opportunity cost of understocking, and risk associated with demand forecasts. The function is weighted to balance profit and risk considerations. A Monte Carlo Simulation generates a sample of demand levels from the style's distribution, to optimize the order quantity using the average utility value at the different demand levels. A simplified analysis is first adopted, ignoring minimum order commitments. The recommended first production quantities, derived from the simulation, ascend to 11,900 units for the ten styles combined. The minimum order quantity constraints by suppliers are then introduced to the equation. An expanded optimization problem considers both first and second production orders in scenarios which involve total demand, overstocking, and understocking risks. As a result, adjusted first production quantities are obtained: 12,420 units for Hong Kong and 15,145 units for China. Further scrutiny, leveraging Excel Solver, refines China's quantity to 12,863 units—61% of production capacity—a measured decision ensuring adherence to minimizing understocking risks and allowing flexibility for subsequent orders post the Las Vegas Show by not using up a large portion of the total production capacity in the first order.

The report's second section proposes operational improvements for Sport Obermeyer. These include improvements in demand forecasting through advanced analytics, reduction of supply chain lead times by diversifying suppliers and localizing manufacturing for some raw material, and investments in quality control to enhance production efficiency in China. Furthermore, the algorithmic model, leveraging Monte Carlo simulations, extends to devise a mixed sourcing policy framework balancing intuition with data-driven insights. With that, short-term considerations emphasize improving input quality for this sourcing policy model, while long-term considerations involve strategic investments in Chinese production, considering geopolitical risks, supply chain diversification, and return on investment studies.

The analysis included in this report presents a comprehensive strategy for Sport Obermeyer, suggesting immediate production optimization and long-term operational enhancements.

Introduction

Sport Obermeyer, founded in 1947 by Klaus Obermeyer, specializes in ski wear and equipment. Fast forward to 1992, almost half a century since its inception, Wally Obermeyer is preparing for the release of the 1993-1994 skiwear line. This report addresses questions on the efficiency of the supply chain and makes recommendations regarding the first production order for their flagship product, the parka.

First Production Recommendations

Sport Obermeyer faces a critical decision-making juncture as Wally Obermeyer, the Vice President, and the Buying Committee need to determine the initial production order for the 1993-94 line. To simplify the problem and foster a better understanding, a subset of parka styles, was chosen by Wally. This subset comprises ten styles, collectively accounting for around 10% of the company's demand. Exhibit 10 includes these styles' demand forecasts performed by the six members of the Buying Committee.

Initial Analysis

Wally established that each style's demand follows a normal distribution with the mean being the forecast average and the standard deviation being double the forecast standard deviation. The primary objective is to recommend the first production order quantity for each style, considering specific criteria. Firstly, as mentioned, demand for each style follows a normal distribution. Secondly, price variations and minimum order commitments are not to be factored into the initial analysis. Additionally, the profit from selling one parka unit during the season is 24% of wholesale price, while the loss from selling one unit after the season during inventory liquidation is 8%. Finally, the maximum monthly production capacity for the subset styles is 3,000 units, accumulating to 21,000 units over a 7-month production span, noting that an initial order of 10,000 parkas allows for sufficient capacity for a later order.

The problem at hand is viewed as an optimization problem aimed to maximise the utility of Sport Obermeyer amid all the uncertainty associated with the demand levels. It is important to note that if price variations were considered, the optimization would have been approached at an aggregate level for all ten styles, rather than on an individual style basis. The initial phase of the optimization involves defining the utility or objective function to be maximised per style, incorporating the following elements:

1. **Profit** per sold parka unit, varying based on whether units are sold during the season (24% profit) or after the season during inventory liquidation (8% loss). The net profit serves as a reinforcement (increase) to the objective function.

2. **Opportunity cost of under-stocking** for units in demand during the season but are unavailable, leading to a lost profit of 24%. An interesting observation is that the opportunity cost of understocking is three times the cost of overstocking, which might tempt an indiscriminate decision to maximize production. However, it is crucial to acknowledge the company's production capacity constraints. Blind

production escalation also overlooks the competitive landscape in the market. The opportunity cost acts as a penalty (reduction) of the profit and thus the objective function.

3. **Risk associated with each forecast**, where less confidence is placed in forecasts experiencing higher uncertainty. In a world of zero uncertainty, the optimal Cycle Service Level; referred to as CSL hereinafter, would be defined as $\frac{\text{Cost of Understocking}}{\text{Cost of Understocking+ Cost of Overstocking}}$, resulting in a CSL of 75%. However, in the present case, varying levels of uncertainty exist within the distribution of each parka style and around the normal distribution assumption itself and the distribution's parameters. Uncertainty within the distribution is quantified using the coefficient of variation, calculated as $\frac{\text{standard deviation}}{\text{mean}}$. This measure is then utilized to formulate a metric resembling a target CSL, inversely correlated with the coefficient of variation. The rationale behind this metric is that for styles with low uncertainty, the company aims to meet demand as close to 100% of the time as possible and secure a substantial initial production. Conversely, for styles with high uncertainty, the company aims to limit its initial production until more certainty is obtained through the Las Vegas Show orders. The gap between this "target CSL" and the resulting CSL of the order quantity acts as a penalty (reduction) of the objective function.

The objective function incorporates an arbitrary weighting for each of the two elements (profit and risk). 50% weight is assigned to the profit-related measures (components 1 and 2 described earlier), while the remaining 50% weight is allocated to the uncertainty measure presented in component 3. The definition of the objective function, in the form of an R Programming Language function, is provided in Appendix 1.

To optimize this objective function, knowledge of the demand distribution is utilized through a Monte Carlo Simulation By generating a sample of demand levels from the style's distribution, the simulation estimates an average objective function value for a pre-specified order quantity. A range of order quantities is considered, and the one that maximizes the objective function value is selected as the total order quantity, from which the first production size is determined to be half of the total quantity[1]. It is crucial to highlight a limitation of the demand normal-distributed random generator, which occasionally yields negative demand. These negative values were excluded from the optimization. The complete R code used for running the simulation and generating the order quantities is included in the HTML document accompanying this report. Note that this code includes other simulations that will be discussed in the next section of this report.

As depicted in the below table, the recommended first order quantity sums up to 11,900 units, requiring around 3.9 production months and utilising 57% of the production capacity. Although this proportion is higher than what is desired for the first production (50% or less), we consider it to be a reasonable choice.

Question 1: Recommended First Production Quantities (Total = 11,900 units)

Gail	Isis	Entice	Assault	Teri	Electra	Stephanie	Seduced	Anita	Daphne
677	586	841	1655	607	1209	424	2640	1840	1421

[1] Chart 1 displays the recommended total quantities compared to the committee's average forecast.

A More Realistic View: Minimum Order Quantities

In the initial analysis for recommending the first production order quantity, two crucial considerations were considered: the absence of a minimum order quantity restriction and the non-consideration of price variations. To enhance the realism of the analysis, we now revisit the assumption regarding the lack of a minimum order quantity, given that both suppliers—Hong Kong and China—impose a minimum order quantity requirement per style, where Hong Kong imposes a minimum of 600 units/style and China imposes a minimum of 1200 units/style.

An uncomplicated approach to address these minimum quantities is to review the initially recommended quantities and round up any style falling below the minimum order quantity. However, this method is short-sighted and fails to consider the second production order, which is also constrained by minimum commitments, thereby neglecting the optimization of the total order quantity per style. Instead, we work on expanding the optimization problem introduced earlier, along with its associated objective function, to encompass the entire production process. Rather than optimizing the total order quantity and dividing by 2 to determine the first production, the optimization problem aims to optimize the first production quantity by considering various simulated demand levels and their interaction with the first and second production. For that, multiple scenarios are considered. The scenarios assume that Sport Obermeyer has already placed the first order quantity under analysis and has progressed to a stage where they can make decisions about the second order after the Vegas show. Consequently, the simulated second order quantities are made to maximise profit at that specific point. The scenarios are as detailed, noting that the first order quantity is controlled to abide by the minimum order quantity:

- **Scenario 1:** The first order quantity exceeds the style's total demand. In this case, to minimize overstocking losses, Sport Obermeyer would refrain from making a second order. Profit, in this instance, would be the sales profit for the demanded units, less the overstocking cost.
- **Scenario 2:** The style's total demand surpasses the first order quantity but falls short of justifying a second order meeting the minimum quantity. Here, the company would opt for the lesser of two losses—either making a second order of the minimum quantity incurring an overstocking cost or not making a second order incurring an understocking cost for the lost sales.
- **Scenario 3:** The style's total demand is large enough to allow for two orders that meet the minimum order quantity in which case the company can order the total demand, over the two production orders, and would neither incur an overstocking or understocking cost. Admittedly, it must be acknowledged that this assumption is somewhat simplistic, as it overlooks the consideration of a maximum limit on the number of units per style the company can produce, considering the production of other styles concurrently. The scenarios described above were included in the objective function used to calculate the first order recommendation quantities for Hong Kong and China.

The definition of the objective function is included in the accompanying HTML document, and the results summary is included in Appendix 2.

Following the simulation under minimum order quantity constraints, the first production quantities increased to 12,420 units for Hong Kong and 15,145 units for China, as shown in the below tables.

Question 2: Recommended First Production Quantities – Hong Kong (Total = 12,420 units)

Gail	Isis	Entice	Assault	Teri	Electra	Stephanie	Seduced	Anita	Daphne
772	603	950	2174	602	1148	600	3747	600	1224

Question 3: Initial Recommended First Production Quantities – China (Total = 15,145 units)

Gail	Isis	Entice	Assault	Teri	Electra	Stephanie	Seduced	Anita	Daphne
1200	1200	1200	1960	1200	1299	1200	3310	1203	1373

After optimizing quantities for both countries based on mathematical considerations and accounting for minimum order quantities, an additional factor was considered. Due to the high uncertainty in demand, it is reasonable to minimise the quantities for the initial order. From a business perspective, it would not be wise to consume more than 60% of the production capacity in the first order, to leave enough margin for the second order after the Vegas show. With this assumption in mind, producing 12,420 units from Hong Kong will consume 59% of the capacity, which goes in line with the premise. However, ordering 15,142 units in the first order from China consumes 72% of the capacity, which is risky and leave limited flexibility to even relocate between styles productions in the second order. For that reason, it would be appropriate to take a more prudent approach and reduce the first order while minimising the understocking cost without straying away much from the initially recommended first order by the R optimization function.

The Solver tool in Excel (refer to Appendix 4 and accompanying excel sheet) was employed for this approach, taking into account style prices to assess the potential risk of understocking resulting from reducing the first order, with no guarantee of a second order, considering it may not meet the minimum order commitment. Logically the styles with lower understock cost per unit will be reduced. The problem was framed as a straightforward optimization problem, with first-order quantities per style as decision variables and the total understock cost across all styles as the objective function, based on the reduction in first-order quantities compared to optimal values recommended by the R function. To uniformly decrease quantities per style, a constraint was formulated: style quantity should exceed the maximum of $1200 (minimum order quantity) and half the average forecast, providing a 50% chance of meeting demand on a total production level. As a result, the styles that were reduced are: Assault, Electra, Seduced, Anita and Daphne. The final recommended first-order quantity for China totals 12,863, representing 61% of the total capacity, in line with the 60% benchmark.

Question 3: Final Recommended First Production Quantities – China (Total = 12,863 units)

Gail	Isis	Entice	Assault	Teri	Electra	Stephanie	Seduced	Anita	Daphne
1200	1200	1200	1263	1200	1200	1200	2009	1200	1192

A final remark to be made is that, for five styles, the optimal quantity is being increased to reach the minimum requirement from China. Basically, if Sport Obermeyer exclusively orders from China, there's limited room for optimization. Instead, adhering to their strategy of splitting orders between China and Hong Kong seems prudent, where it could order from China those styles where the optimized quantities are larger than the minimum requirements, like Assault, Electra, Seduced, Anita and Daphne and order the rest of the styles from Hong Kong. The sourcing policy between China and Hong Kong will be discussed in more detail in a later section of this report.

Operational Recommendations

Stepping back from the immediate task of determining the 1993-1994 first production order, we delve into the operational context of Sport Obermeyer, where several operational enhancements can be recommended to improve performance and face the growing market competition in recent years. As highlighted, there is a great financial risk associated with the opportunity cost of understocking. The risk also extends beyond financial implications, as it holds significant impact on the company's market share, posing a threat to their market reputation and positioning. In the context of the Sport Obermeyer industry, skiing clothing is essential for individuals engaging in sports in extreme weather. Consequently, if customers cannot find Obermeyer products available, they are more likely to purchase alternatives rather than cancel their plans altogether. This would result in a loss of market share and decline in brand power for Obermeyer. Brand power (or market power) has a crucial effect on a firm's profitability (Buzzell et al, 1975). Economic theory illustrates that market share is related to firm profit through three pillars, as depicted in Figure 1. It is crucial for Sport Obermeyer to strike a balance between the risk of understocking and overstocking, where not only the opportunity understocking cost is greater than the overstocking cost, but the costs associated with the positioning of the brand must also be considered when products are unavailable at the retail level.

With that in mind, we begin sharing operational recommendations to address the operational hurdles and main pain points outlined in the case study, including demand forecasting accuracy, extended lead time across the supply chain, and production sourcing considerations between Hong Kong and China. It is important to note that the recommendations provided, while still largely relevant in the present day, are presumed to be presented to Wally Obermeyer in 1993-1994 when this case study was established.

Demand Forecasting

It is pivotal for Sport Obermeyer to optimize its production processes through enhanced demand forecasting. Implementing machine learning models and analytics tools, such as predictive algorithms, can analyse a comprehensive range of data including historical sales patterns, market trends, seasonality, consumer behaviours, and even digging deeper to external factors like weather patterns. Incorporating such technologies ensures a more granular and accurate understanding of consumer demand, not only at a parka style level, but also at a size and colour level. Addressing the issue of underproduction, which Sport Obermeyer has historically faced with its most popular items, by leveraging advanced analytics, the company can better predict which products are likely to become best-sellers and adjust production quantities accordingly. Moreover, this will allow to match the supply to market demand, reducing both underproduction and overproduction risks.

Fast-forwarding to the present day, new technologies relying on artificial intelligence (AI) have been developed that would have been part of the recommendations if the case study was set in the current era. A specific technology that can be highly beneficial is “Demand Sensing Software”, which uses AI to analyse real-time market data and predict future demand more accurately, adjust forecasts based on immediate changes, providing a more dynamic and responsive approach to demand forecasting.

To put things into perspective, considering the smaller-scale issue involving the sample of 10 parka styles in Exhibit 10, the average wholesale price per parka is $112. This implies that the cost of a lost sale (underproduction) per unit is $27 (24% * $112), while the cost of overproduction per unit is $9 (8% * $112). Assuming a potential improvement of 1% in forecast accuracy (a reasonable arbitrary estimate) through advanced analytics, with the company producing approximately 200,000 units annually, closing the misallocation gap of 2,000 (1% * 200,000) units between styles could transform a potential loss of $72,000 into a profit of $54,000. The potential loss includes an overproduction cost of $18,000 (2000 * $9) and an underproduction opportunity cost of $54,000 (2000 * $27).

Supply Chain Lead Times

Enhancing demand forecasting addresses only part of Sport Obermeyer's challenge of extended lead times in its supply chain. To address the root issue, the company should further diversify its supplier base and localize manufacturing closer to hubs, reducing dependency on distant suppliers and improving responsiveness to demand changes. This strategic shift should be closely integrated with the marketing department, aligning with market research insights. In a high-level this involves considering three stages: upstream, midstream, and downstream. Diversifying suppliers at the beginning of the supply chain by sourcing raw materials from various locations, potentially closer to the manufacturing hubs, can significantly reduce the time to get materials into the production cycle. Localized suppliers in the manufacturing phase enable quicker turnaround times for products ready for distribution. Shorter lead times in distribution and retail ensure products reach the market faster, aligning closely with consumer demand and seasonal trends.

Examining materials crucial for parka production reveals that while standard items like snaps are easily kept in stock and are thus not restrictive, others like zippers (60-90+ days lead time) and shell fabric (45-60 days for material plus 45-60 days for dying and printing) pose challenges. Shell fabric preparation, a critical initial step, acts as a bottleneck, delaying the entire process if hindered. Therefore, while improving lead times on all materials would be beneficial, it is recommended for Sport Obermeyer to firstly focus on the shell fabric acquisition and dying process. To improve lead times without compromising quality, Sport Obermeyer can relocate part of the dying/printing process to factories near sewing and cutting facilities.

From a quantitative benefit perspective, assuming the lead time from a distant supplier is 90 days and a local supplier can reduce this to 45 days, this 50% reduction in lead time could improve response to market demand enabling flexibility. Example wise, a 3% increase in sales during peak periods on their annual sales of $32.8 million could lead to an additional $0.98 million in revenue, which is a considerable change for the management. Additionally, this change will lead to the reduction in transportation costs.

Quality Control

Progressing further into the supply chain, transitioning from production materials to the sewing and cutting stages, we address the dilemma around expanding China's manufacturing share from one-third to half of the total production. Despite the advantages in labour cost savings, China's benefits are counteracted by drawbacks compared to Hong Kong, as outlined in Exhibit 8. These drawbacks include production lines that are more than three times longer, requiring a larger workforce, decreased productivity due to lower skill levels, and heightened defect rates. While changing manufacturers may seem like a plausible solution to address production quality, the enduring partnership between Obermeyer and Obersport, coupled with the circumstances surrounding Obersport's expansion with the new Lo Village factory in China, suggests a different strategy. The recommended approach begins with an investment in training to improve the long-term quality of the new factory, fostering a stronger partnership. This strengthened collaboration could eventually lead to an expansion of manufacturing capacity, transitioning Obermeyer from sub-contractors to a more loyal and trained supplier.

The new factory is situated in a small village in China, reflecting a community-focused business approach. By investing in quality control, Obermeyer, and its partner (Obersport), not only improve the product, but also contribute to the community where the factory is based. In such communities, stable employment is highly valued, and the workforce is likely to show loyalty to an employer that invests in their skills and well-being. This suggests minimal risk of trained workers leaving the factory after receiving training. Consequently, this investment is not just about improving the product quality; it is also about building a loyal, skilled workforce and contributing positively to the local community. In essence, investing in quality control will reduce the defect rate in products manufactured in China, which directly translates to lower costs associated with returns and repairs, expanded production capacity, increases customer satisfaction, and strengthens long-term business relationships.

Currently, the defect rate at the China factories stands at 10%, with 4.88 paid labour hours required per parka (compared to 2.53 hours in Hong Kong factories) and a production line cost of $10 per parka. The estimated cost to produce 200,000 units is around $156,000 (see Appendix 5). Assuming a reduction in the defect rate and an increase in productivity to achieve a requirement of 4 paid labour hours per parka (arbitrary assumption), the labour cost to produce 200,000 parkas would decrease to $128k, resulting in an annual saving of $28k (18% saving).

Further, with the increased production efficiency, Sport Obermeyer can respond more swiftly to market demands and replenishment orders, potentially capturing more sales. Similar calculations, as outlined in the last recommendation, can be applied here, demonstrating that increased sales impact on revenues.

Sourcing Policy: Hong Kong versus China

The operational recommendations serve as a foundation for addressing Sport Obermeyer's challenges and are integral to the broader sourcing strategy. The focus on demand forecasting, supply chain lead times, and quality control not only addresses immediate operational hurdles but lay the groundwork for a more informed and data-driven approach to the decision-making process in sourcing. Now, we provide a framework to support these decisions with algorithms to deal with the uncertainty around demand.

How to Think about the Sourcing

It is clear from the case that Obermeyer rely too much on the intuition and expertise of their managers to make the procurement decisions. We highlight that there is a lot of uncertainty around the geopolitical landscape of the region, as well as for the demand of the products, which often involve new launches that have no historical data. In this setting, we propose a mixed approach to the decision-making process, where we develop an algorithm similar to what has been proposed in the First production recommendation section. That way, some of the uncertainty regarding the future demand can be dealt with by employing the Monte Carlo method, thus providing a tool to support the sourcing decision a given product.

Policy for Procurement from China or Hong Kong for Product i

The approach is similar to finding the optimal product availability given the normal sale price (p_i), the sale price of overstocked products (p_{oi}), the opportunity cost due to understocking (p_{ui}) and the procurement costs for each country, c_c *and* c_h, for China and Hong Kong respectively. We add to this optimization function the constraints related to the minimum quantities. Furthermore, we add additional terms related to the quality aspects of each plant (q_c *and* q_h), where the index c stands China and h for stands for Hong Kong. This indexing will be used in other variables defined later. Finally, we add a risk factor for Chinese production to quantify the other external risks associated with procuring from China, given the possible export quota limitations (ξ_c).

The true demand of a product i is u_{di}. The total produced amount is u_{pi} and the total sold amount is u_{si}. The true demand and total sold amounts are unknown, whereas the production amount is the decision variable of the objective function. The total produced units can be broken down into: $u_{pi} = u_{pic} + u_{pih}$.

$$P = p_i \times u_{si} - c_c \times u_{pic} - c_h \times u_{pih} - p_{oi} \times [u_{pi} - u_{si}] - p_{ui} \times [u_{di} - u_{pi}] - q_c \times c_c \times u_{pic} - q_h \times c_h \times u_{pih} - \xi_c \times x_c$$

Subject to

$$either\ u_{pic} = 0\ or\ u_{pic} \geq 1200\ ;\ either\ u_{pih} = 0\ or\ u_{pih} \geq 600$$

$$if\ u_{pic}\ > 0\ then\ x_c\ = 1;\ x_c\ \in \{0,1\},\ u_{pic},\ u_{pih}\ \geq\ 0,$$

The variables q_c or ξ_c should be treated as parameters of the model, tuned by the management team with support from specialists in the respective areas. Given that the demand and sold quantities are unknown, we will modify the formulation to leverage again the Monte Carlo method. We define a random variable $U_{di}\ \sim\ N(\mu_i,\ \sigma_i)$ as an estimator for the true demand. We can use either the estimations provided by the department heads as we have done in the First production recommendation section or improve our estimations by making a deeper analysis of historical values. With that, we derive two functions. The first is about the overstock quantity.

$$f_{oj}\ =\ 0\ if\ u_{dij}\ \geq\ u_{pi}\ ;\ f_{oj}\ =\ u_{pi}\ -\ u_{dij}\ if\ \ u_{dij} < u_{pi}$$

Where u_{dij} is the j-th sample of the U_{di} random variable. Similarly, we define the understock quantity as:

$$f_{uj}\ =\ 0\ if\ u_{pi}\ \geq\ u_{dij}\ ;f_{uj}\ =\ u_{dij}\ -\ u_{pi}\ if\ u_{dij}\ >\ u_{pi}$$

Finally, we define the sold quantity as:

$$f_{sj}\ =\ u_{pi}\ if\ u_{dij}\ \geq\ u_{pi}\ ;f_{sj}\ =\ u_{dij}\ if\ u_{pi}\ \geq\ u_{dij}$$

Therefore, we can rearrange the objective function to be a mixed integer problem as below:

$$\hat{P}\ = p_i\ \times f_{sj}\ -\ c_c\ \times u_{pic}\ -\ c_h\ \times u_{pih}\ -\ p_{ui}\ \times f_{uj}\ -\ p_{oi}\ \times f_{oj}\ - q_c\ \times u_{pic} \times c_c\ -\ \xi_c\ \times x_c$$

Where $\hat{P}$ is an array of n values. We can try to optimize the average of this array, where n is the number of samples used in the Monte Carlo estimator. This allows management to test different scenarios with different values of q_c and ξ_c. Appendix 7 shows a summary of the variables used in this equation.

Procurement Decision Considerations

The algorithm developed above provides a guideline for sourcing on a product level, which means that the context of the total production must be considered by the management team separately. This tool provides Obermeyer with a supplement to the management team's intuition about the future demand and market expectations, which can enrich their discussion and make their decision-making process more data driven. Furthermore, we are now able to propose an approach for thinking about the procurement from each supplier both in the short term as well as in the long term.

Short Term Considerations

For the short term, the main aspects to consider are the quality of the inputs fed to the model, that is, the quality of his demand distribution estimation (U_{di}), the quota restrictions that may apply (ξ_c) and the quality ratio of the production in China (q_c). Then, the results need to be carefully assessed by the team. For example, it might suggest shifting all the production to China for a particular product. But management will still need to answer questions such as *what the impacts are given the lack of reliability in delivery*, or *how can the team hedge against the risks associated with China*. On the other hand, there is an opportunity to significantly improve their profitability by switching production to cheaper suppliers, as well as enhancing the China production quality which has personal value to the owners of Obersport.

Long Term Considerations

The long-term considerations are much more focused on where the company can invest and what are the expected returns. The geopolitical scenario is something that needs to be considered carefully. Most of the investments will be centred around investing in procuring from China, but if the future landscape is not favourable, these investments might become too risky. On the other hand, producing in Hong Kong is also not completely risk-free, given its relationship with mainland China. Therefore, the advantages of diversifying the supply chain must be considered as well. After considering these factors, the key areas to invest in the Chinese production would be in relaxing the minimum quantity constraints, reducing lead time, improving the quality of the products, and improving the reliability of the delivery.

To decide how to allocate resources, management should run return on investment (ROI) studies using the optimal value changes. The algorithm developed in this section provides a way to compare scenarios by tuning the inputs of the model. For example, Exhibit 7 tells us that we have about 10% of defects in the products from China. Holding everything equal, management can track the changes in the optimal function if q_c is changed from 10% to 5%.

In conclusion, the proposed sourcing policy for Obermeyer emphasizes the need for a mixed approach in decision-making, combining intuition with an algorithmic model. This model acts as a valuable supplement to managerial intuition, fostering a more data-driven decision-making process. We highlight the importance of input quality of the demand estimations for the new products, quota restrictions, and production standards. The output of the model requires careful assessment by the management team. In the long term, strategic investments in Chinese production should be weighed against geopolitical risks, with an emphasis on diversifying the supply chain and optimizing resource allocation. The framework presented not only guides immediate sourcing decisions but also provides a structured approach for Obermeyer to adapt amidst evolving market dynamics and geopolitical uncertainties.

Conclusion

This study focuses on Sport Obermeyer's key supply-chain decisions, starting with demand forecasting and profit considerations amid uncertainty. It formulates an optimization problem, balancing profit, opportunity cost, and risk. The study aims to find optimal minimum order quantities also considering the context of the suppliers. It aims to provide operational recommendations for improving overall performance, including advanced analytics for demand forecasting, streamlined supply chain lead times, and investments in quality control in the new Chinese factory. A sourcing policy between Hong Kong and China was developed, evaluating cost savings in different settings. We conclude with a mixed decision-making framework, combining managerial knowledge with algorithms, offering insights into business challenges and strategic pathways for Sport Obermeyer's immediate and long-term improvements.

References

Bhattacharya, A., Morgan, N. A., & Rego, L. L. (2022). Examining Why and When Market Share Drives Firm Profit. Journal of Marketing, 86(4), 73-94. https://doi-org.iclibezp1.cc.ic.ac.uk/10.1177/00222429211031922

Buzzell R. D., Gale B. T., Sultan, R. G.M. (1975). Market Share—a Key to Profitability

Appendix

Appendix 1: Q1 Production Objective Function

```
objective_function = function(order_quantity, demand, profit_percentage, loss_percentage, target_CSL,
                              w_profit , w_risk)
{
  #calculate profit per demand level
  net_profit =
    pmin(demand, order_quantity) * profit_percentage - #demanded and sold
    pmax(0, order_quantity - demand) * loss_percentage -  #overstocked
    1*(pmax(0, demand - order_quantity) * profit_percentage) #understocked


  #normalise profit by dividing by the max possible profit (perfectly meeting demand)
  net_profit = net_profit/(demand*profit_percentage)

  #calculate mean of the normalised net profit
  net_profit_mean  = mean(net_profit)

  #calculate squared residual on risk penalty
  risk_penalty = (mean(order_quantity >= demand) - target_CSL)^2


  #calculate combined objective value
  combined_objective = w_profit * net_profit_mean - w_risk * risk_penalty
  return(combined_objective)
}
```

Please refer to the accompanying HTML document included in the submitted zipfolder for the complete code.

Appendix 2: Recommended Production Quantities (Q1-Q3)

Please refer to the accompanying HTML document included in the submitted zipfolder.

The consolidated output of the R code for questions 1-3 is shown in the following table, which is included in 'Appendix 2' worksheet in the attached excel spreadsheet "Excel Appendices" in the submitted zip folder.

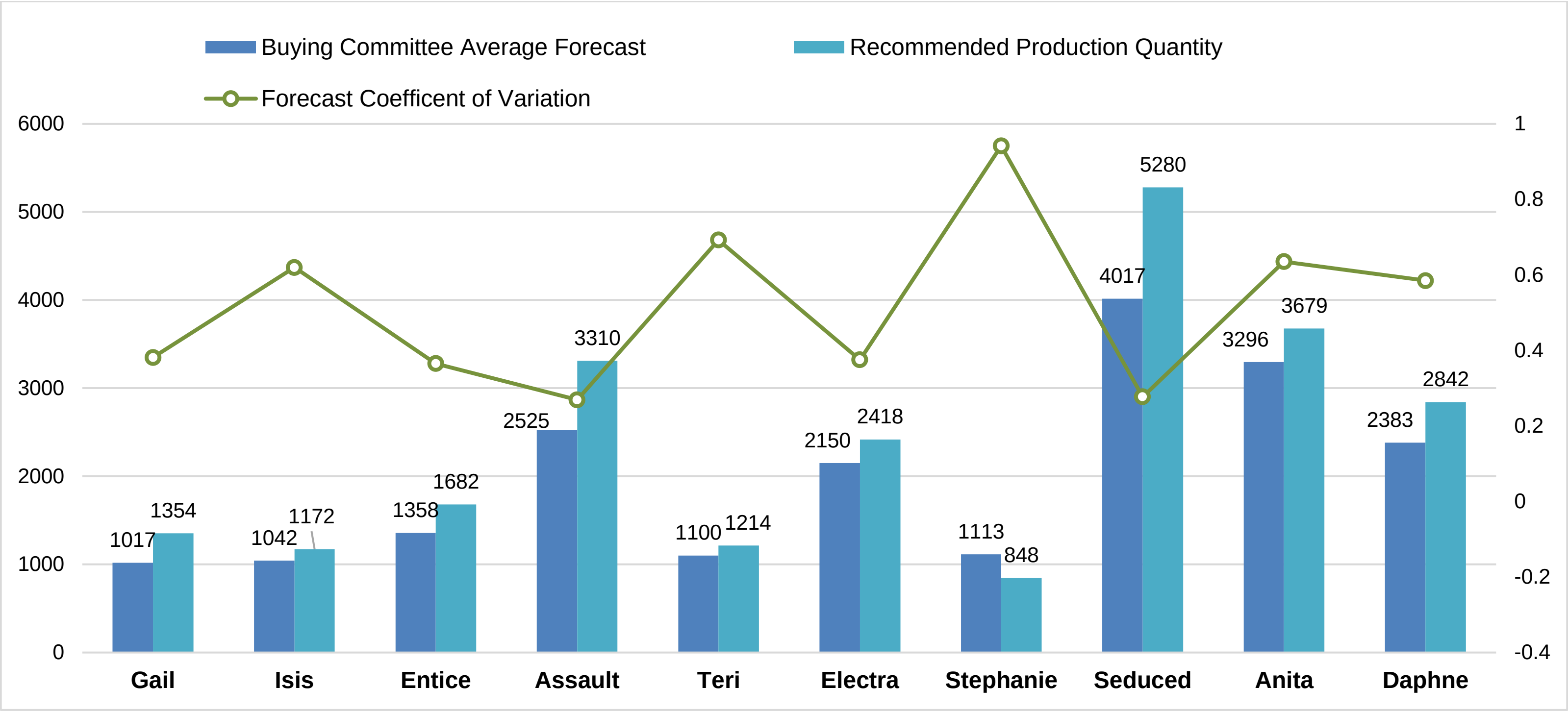
Output Table from R code

Production Capacity 21,000

						Recommended First Production by R		
						Q1	Q2	Q3
Style	**Price**	**Average_Forecast**	**Standard_Deviation_x2**	**coef_of_var**	**total_order_quantity**	**first_order**	**first_order_HK**	**first_order_C**
Gail	110	1,017	388	0.38	1,354	677	772	1,200
Isis	99	1,042	646	0.62	1,172	586	603	1,200
Entice	80	1,358	496	0.37	1,682	841	950	1,200
Assault	90	2,525	680	0.27	3,310	1,655	2,174	1,960
Teri	123	1,100	762	0.69	1,214	607	602	1,200
Electra	173	2,150	807	0.38	2,418	1,209	1,148	1,299
Stephanie	133	1,113	1,048	0.94	848	424	600	1,200
Seduced	73	4,017	1,113	0.28	5,280	2,640	3,747	3,310
Anita	93	3,296	2,094	0.64	3,679	1,840	600	1,203
Daphne	148	2,383	1,394	0.58	2,842	1,421	1,224	1,373
Total		**20,001**				**11,900**	**12,420**	**15,145**
Num of Months to produce						3.97	4.14	5.05
Consumption of Total Production Capacity						57%	59%	72%

Appendix 3: Q1 Total Recommended Order Quantity versus Committee Forecast

Chart 1



Appendix 4: China Recommended First Order – Excel Solver Setup

‘Appendix 4’ worksheet in the attached excel spreadsheet “Excel Appendices” in the submitted zipfolder.

Capping China First Order

Cost of Understock	24%
Min China Order	1,200
Production Capacity	21,000

					Recommended First Production by R				Final Recommended China First Order	
					Q1	Q2	Q3		Q3	
Style	**Wholesale Price**	**Average_Forecast**	**Standard_Deviation_x2**	**coef_of_var**	**first_order**	**first_order_HK**	**first_order_C**	**Min Production Constraint_C**	**Decision Variable_C**	**C_u**
Gail	110	1,017	388	0.38	677	772	1,200	1,200	1,200	0
Isis	99	1,042	646	0.62	586	603	1,200	1,200	1,200	0
Entice	80	1,358	496	0.37	841	950	1,200	1,200	1,200	0
Assault	90	2,525	680	0.27	1,655	2,174	1,960	1,263	1,263	15,066
Teri	123	1,100	762	0.69	607	602	1,200	1,200	1,200	0
Electra	173	2,150	807	0.38	1,209	1,148	1,299	1,200	1,200	4,110
Stephanie	133	1,113	1,048	0.94	424	600	1,200	1,200	1,200	0
Seduced	73	4,017	1,113	0.28	2,640	3,747	3,310	2,009	2,009	22,802
Anita	93	3,296	2,094	0.64	1,840	600	1,203	1,200	1,200	67
Daphne	148	2,383	1,394	0.58	1,421	1,224	1,373	1,192	1,192	6,447
Total		**20,001**			**11,900**	**12,420**	**15,145**		**12,863**	**48,493**
Num of Months to produce					3.97	4.14	5.05		4.29	
Consumption of Total Production Capacity					57%	59%	72%		61%	

Appendix 5: Production Cost per Parka

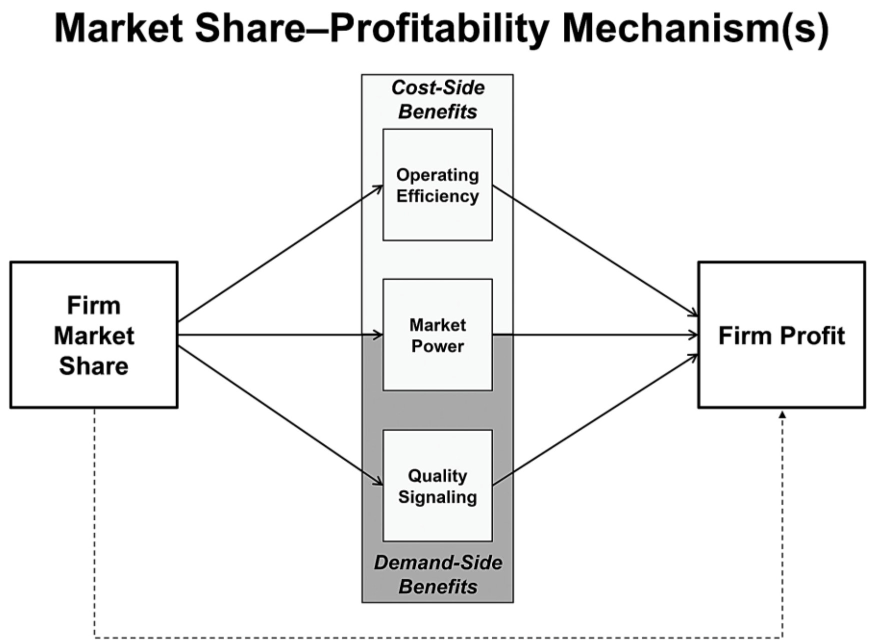
'Appendix 5' worksheet in the attached excel spreadsheet "Excel Appendices" in the submitted zipfolder.

Hong Kong vs China Production Cost Comparison

		Hong Kong	China	China to Hong Kong Ratio
(a)	**ROE (Local Curreny to $)**	7.80	5.70	
(b)	**Hourly Wage (local currency)**	30.00	0.91	
(c) = (a) x (b)	**Hourly Wage ($)**	$3.85	$0.16	0.04
(d)	**Paid Labor Hours per parka**	2.53	4.88	1.93
(e)	**Number of People per line**	11	40	3.64
(f) = (c) x (d)	**Cost of Labor Line per parka ($)**	$9.73	$0.78	0.08
(g)	**Weekly Production capacity (per line)**	19	12	0.63
(h) = (g) x 4 weeks x 7 months	**7 months production capacity (per line)**	532	336	0.63
(i)	**Repair Rate**	1.50%	10.00%	6.67
(j) = 200000 ÷ (h)	**Number of lines to produce 200K units**	376	596	1.59
(k) = (f) * 200000	**Cost of 200K units**	$1,946,154	$155,818	0.08

Appendix 6: Firms market share and profit relation

Figure 1 (Bhattacharya et al, 2021)



Appendix 7: Summary of Variables in the Procurement Policy

Variable	***Description***
p_i	Policy price of item i
f_{sj}	Effective sold quantity of item i in the j-th sample
c_c	Cost of procurement from China
u_{pic}	Units procured from China of item i
c_h	Cost of procurement from Hong Kong
u_{pih}	Units procured from Hong Kong of item i
p_{ui}	Understock price of product i. i.e: Opportunity cost of lacking stock of product i to meet the demand
f_{uj}	Effective understock quantity of item i in the j-th sample
p_{oi}	Overstock price of product i. i.e: price of product I sold at a discount for exceeding demand
f_{oj}	Effective overstock quantity of item i in the j-th sample
q_c	Loss of products due to quality issues from China i.e: that is, how many products do we have to produce in excess to accommodate this risk.
ξ_c	China risk factor
x_c	Support variable which is 1 if material is sourced from China