Optimization of Enterprise Production Decisions Based on Cost-Benefit Model

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Abstract. In the highly competitive business environment of today, enterprises face numerous challenges in production decision-making. The quality of these decisions directly impacts cost control, profit generation, and market competitiveness. Traditional decision-making models often struggle to handle the uncertainties and complex variable relationships in the production process effectively. This paper focuses on this issue and constructs a comprehensive decision system. Firstly, a sampling and hypothesis testing model is established. By applying the central limit theorem, it accurately estimates the defect rate of purchased parts during the procurement process, providing a solid basis for procurement decisions. Subsequently, a cost-benefit model is developed. This model hierarchically analyzes various variables in the production process with multiple processes and spare parts. It derives the profit expression through in-depth research, aiming to achieve cost reduction and profit maximization. Through a practical case study, the total profit and profit margin of different decision combinations are calculated. The research discovers that the optimal combination is to test all semi-finished products and dismantle the unqualified ones. This combination not only exhibits high profitability but also ranks well in terms of total profit, offering valuable guidance for enterprise production decisions and promoting the stable and efficient development of enterprises.

Keywords: Enterprise Production decision, Cost-benefit Model, Sampling Inspection, Hypothesis Testing, Profit Maximization.

1. Introduction

In a highly competitive business environment, the accuracy and scientific nature of enterprise production decisions are crucial for their survival and development. From quality control in raw material procurement to resource allocation and process coordination in complex production processes, the quality of decisions directly relates to enterprise cost control, profit acquisition, and the enhancement of market competitiveness [1, 2]. Traditional decision-making models based on dynamic programming, WITNESS software simulation and others have defects respectively and struggle to effectively handle the numerous uncertainties and complex variable relationships in the production process [3]. In the manufacturing process, cost control and task optimization are of great significance. As suggested in the study of Li et al. (2024), manufacturing enterprises face challenges such as complex tasks and the need for reasonable equipment cycle ordering. Refining tasks into smaller subtasks and arranging equipment procurement and usage cycles rationally can effectively reduce production costs [4]. Moreover, in modern industrial enterprises, the accuracy and efficiency of accounting cost accounting play a vital role. Liang (2025) pointed out that traditional cost calculation methods often encounter problems like information lag and low data processing efficiency, which can be improved by applying modern technologies such as mixed integer linear programming, data mining, and artificial intelligence [5]. This research centers on the crucial decision-making aspects in enterprise production. It constructs a decision-making system based on advanced mathematical models. A sampling and hypothesis testing model is established to estimate the defect rate of purchased parts using the central limit theorem in the procurement process. By setting parameters like significance level and test power, it derives the sample size formula and confidence interval [6]. Additionally, a cost-benefit model is developed. For production systems with multiple processes and spare parts, it designs hierarchical variable systems. Through comprehensive analysis, the total profit formula is obtained and the decision space is explored to achieve cost reduction and profit maximization [7]. Case studies show that the combination of testing all semi-finished products and dismantling unqualified ones has high profitability and a good total profit ranking, demonstrating the effectiveness of the models in enhancing enterprise production decision-making.

2. Methodology

2.1. Sampling Inspection and Hypothesis Testing Model

2.1.1. Distribution Assumption and Approximation Procedure

In the critical process of enterprise procurement of spare parts, the defect rate is accurately set as p, and n samples are drawn according to a strict sampling process. Currently, the number of nonconforming items X strictly follows a binomial distribution X ~B (n, p), and its expectation E = np and variance D = np (1− p) precisely measure the distribution law of the number of defective products. When the sample size n reaches a sufficient scale, according to the powerful central limit theorem, the distribution approaches a normal distribution $Z = \frac{X - np_0}{\sqrt{np_0(1-p_0)}} \sim N(0,1)$ (where p_0 is the nominal defect rate promised by the supplier), and the sample defect rate $\hat{p} = \frac{X}{n}$. Through strict mathematical derivation, the normal test statistic is elegantly simplified to $Z = \frac{\hat{p} - p_0}{\sqrt{\frac{p_0(1-p_0)}{n}}}$ [8, 9]. This simplified formula unlocks the key to the quantitative evaluation of the defect rate and lays a solid data foundation for subsequent procurement decisions [10].

2.1.2. Sample Size Computation and Decision-making Criterion

Carefully set the significance level α (accurately defining the probability boundary of wrongly rejecting the null hypothesis $p \le p_0$ when it is true) and the test power 1 − β (clearly defining the probability bottom line of correctly rejecting the null hypothesis when it is false), and derive α through the ingenious deduction of the confidence level formula. Deeply explore the strict conditions for rejecting the null hypothesis and accurately detecting the expected defect rate p_1, and then derive the sample size calculation formula

$$n = \frac{(Z_{\alpha/2} + Z_{\beta})^2 \cdot p_0 \cdot (1 - p_0)}{(p_1 - p_0)^2} \tag{1}$$

(Where $p_1 - p_0$ is the tolerance error E preset by the enterprise). Further calculate the confidence interval $\hat{p} > Z_{1-\alpha}\sqrt{\frac{p_0(1-p_0)}{n}} + p_0$ by using the powerful computing ability of the normal distribution. Based on this accurate quantitative scale, enterprises can clearly judge the quality of spare parts batches in the complex procurement decision-making process and optimize the delicate balance between procurement cost and quality.

2.2. Cost-benefit Calculation Model (Multi-process and Multispare Part Scenario Expansion)

2.2.1. In-depth Insight into Model Variables and Fine Hierarchical Architecture

For the complex and diverse production systems with m processes and n spare parts, this model carefully crafts a variable system for each level. In the spare part layer, binary inspection variables $X_1^1, X_2^1, \cdots, X_n^1$ and cost variables $P_1^1, P_2^1, \cdots, P_n^1$ are ingeniously set, which are like implanting intelligent decision chips for each spare part to accurately perceive the strategy choice of inspection and the ripple of cost changes. The semi-finished product layer is delicately stratified according to the evolution of the process, and exclusive inspection and cost variable matrices are customized for each level to accurately capture the value flow and cost precipitation trajectory of semi-finished products in the production process. The finished product layer uses simple but key inspection variable X^m and cost variable P^m to complete the quality control and cost accounting of the finished product. This hierarchical and logical variable architecture precisely depicts the dynamic interaction panorama of cost-benefit elements in the production process.

2.2.2. Deep Derivation and Connotation Interpretation of Total Profit and Profit Margin Expressions

Based on a comprehensive and three-dimensional analysis of the cost-benefit of the production process, the total profit formula

$$P = \max(U - \eta_1 - \eta_2 - \eta_3 - \eta_4 - \eta_5 + \eta) \tag{2}$$

Is constructed. Among them, U, as a key variable of the selling price of the finished product, guides the direction of the profit target; the η_1 represents the total cost of purchasing each component, η_2 is the total inspection cost calculated based on the inspection variables and cost variables, η_3 is the dismantling cost calculated based on the dismantling strategies and related cost variables, η_4 is the estimated cost of finished product replacement losses, η_5 is the total assembly cost, and η is the expected total dismantling revenue. The corresponding profit margin formula $l = \frac{P}{P_1} \times 100\%$ (P_1 is the total revenue) clearly reflects the real quality of enterprise operating efficiency. Through the efficient traversal algorithm, the vast decision combination space is deeply explored to achieve the simultaneous progress of cost reduction and profit maximization.

3. Case Study

3.1. Assumptions Based on Business Realities

A scenario of production decision making in an enterprise is simulated to verify the effectiveness of this model. Suppose an enterprise to produce a kind of finished product requires a total of 8 spare parts, where in the first process, parts 1, 2, 3 can be synthesized into semi-finished product No. 1, 4, 5, 6 can be synthesized into semi-finished product No. 2, 7, 8 can be synthesized into semi- finished product No. 3, three semi-finished products can be synthesized into a finished product in the second process. Meanwhile, the enterprise's expenses in the production and sales process in the grid are shown in Table 1.

Table 1. Costs related to the production and sales process of the enterprise.

Numbering of Spare Parts	Defective Rate	Unit Cost of Purchase (¥)	Testing Costs (¥)	Numbering of Semi-finished Products	Defective Rate	Unit Cost of Purchase (¥)	Testing Costs (¥)	Dismantling Costs (¥)
1	10%	2	1	1	10%	8	4	6
2	10%	8	1	2	10%	8	4	6
3	10%	12	2	3	10%	8	4	6
4	10%	2	1					
5	10%	8	1	Finished Products	10%	8	6	10
6	10%	12	2					
7	10%	8	1		Market Price (¥)		Exchange Losses (¥)	
8	10%	12	2	Finished Products	200		40	

3.2. Model Building

Based on the cost-benefit model, we can set the total number of spare parts n=8, the number of each spare part purchased as N, the defective rate as D, the binary variable indicating whether the ith component in the jth layer is detected or not is X_i^j, which will be denoted by the binary variable of whether the cost is detected or not as X^3, the variable indicating the cost of detecting the ith component in the jth layer is P_i^j, and the variable indicating whether or not the ith component of the jth layer is disassembled is R_i^j (j=2,3). Thus, the corresponding expressions for the quantities of semi-finished and finished products can be obtained:

$$\begin{cases} S_1^2 = \min\{(1-X_1^1 \cdot D)\cdot N, (1-X_2^1 \cdot D)\cdot N, (1-X_3^1 \cdot D)\cdot N\} \\ S_2^2 = \min\{(1-X_4^1 \cdot D)\cdot N, (1-X_5^1 \cdot D)\cdot N, (1-X_6^1 \cdot D)\cdot N\} \\ S_3^2 = \min\{(1-X_7^1 \cdot D)\cdot N, (1-X_8^1 \cdot D)\cdot N\} \\ S_1^3 = \min\{(1-X_1^2 \cdot D)\cdot N, (1-X_2^2 \cdot D)\cdot N, (1-X_3^2 \cdot D)\cdot N, (1-X^3 \cdot D)\cdot N\} \end{cases} \tag{3}$$

Where S_1^2, S_2^2, S_3^2, and S_1^3 denote the number of semi-finished products No. 1, No. 2, No. 3, and finished products respectively. The number of finished goods can only be the minimum of the two-part numbers since the inspection of spare parts rejects defective parts, thus reducing the number of parts that can be used for assembly.

Since the number of qualified products is the product of the number of finished products and the rate of qualified products. If a semi-finished or finished product is qualified, it needs to satisfy the elements of qualified spare parts and qualified assembly. Therefore, according to the above number of semi-finished products and finished products, we get the expression of the corresponding number of qualified products:

$$\begin{cases} I_1^2 = (1-D)\cdot(1-(1-X_1^1)\cdot D)\cdot(1-(1-X_2^1)\cdot D)\cdot(1-(1-X_3^1)\cdot D)\cdot S_1^2 \\ I_2^2 = (1-D)\cdot(1-(1-X_4^1)\cdot D)\cdot(1-(1-X_5^1)\cdot D)\cdot(1-(1-X_6^1)\cdot D)\cdot S_2^2 \\ I_3^2 = (1-D)\cdot(1-(1-X_7^1)\cdot D)\cdot(1-(1-X_8^1)\cdot D)\cdot S_3^2 \\ I_1^3 = (1-D)\cdot(1-(1-X_1^2)\cdot D)\cdot(1-(1-X_2^2)\cdot D)\cdot(1-(1-X_3^2)\cdot D)\cdot S_1^3 \end{cases} \tag{4}$$

Where I_1^2, I_2^2, I_3^2, and I_1^3 denote the number of semi-finished products 1, 2, and 3 as well as the number of qualified products in the finished product, respectively. If spare parts i have not been tested, then $X_i^1 = 0$, i.e., $(1-(1-T_1)\cdot D \ = 1-D$,and therefore the qualified rate of spare parts i needs to be brought into the formula; if spare parts i have been tested, then $X_i^1 = 1$, i.e., $\left(1-\left(1-X_i^1\right)\cdot D = \ 1\right)$, and bring each semi-finished product's spare parts inspection into the formula, we can get the product of the number of finished products and the rate of qualified products, and finally find out the number of qualified products. The second best of these can also be obtained as $S_i^j - I_i^j$.

The dismantling of substandard semi-finished or finished products will result in corresponding spare parts. Since each accessory is only involved in the formation of a semi-finished product, if the semi-finished product containing a certain spare part has not been tested, the substandard rate of a certain spare part in the dismantled object can be calculated directly from the unqualified finished product; if the corresponding semi-finished product has been tested, the con- tent of substandard spare parts in the unqualified semi-finished product can be calculated directly, as shown in the following formula:

Where D_i^1 is the defective rate of the ith spare part in the unqualified finished and semi-finished products, where $i \in [1,\ 8]$. And the denominator part of this expression is $(S_i^j - \ I_i^j)$, which represents the quantity of a certain nonconforming semi-finished or finished product. When calculating the defective rate of spare parts i in unqualified finished products and semi-finished products, if the inspection of spare parts i has been carried out before, i.e., $X_i^1 = 0$, there must be no unqualified spare parts i in the assembled semi-finished products and finished products, and therefore it can be known that $D_i^1 = 0$ according to the above expression.

And for the same reason for the three semi-finished products, it is only neccessary to consider the content of substandard spare parts in the non-conforming finished products:

$$\begin{cases} D_1^1 = \dfrac{X_1^2 \cdot (1-X_1^1) \cdot D \cdot N}{S_1^2 - I_1^2} + \dfrac{(1-X_1^2) \cdot (1-X_1^1) \cdot D \cdot N}{S_1^3 - I_1^3} \\ D_2^1 = \dfrac{X_1^2 \cdot (1-X_2^1) \cdot D \cdot N}{S_1^2 - I_1^2} + \dfrac{(1-X_1^2) \cdot (1-X_2^1) \cdot D \cdot N}{S_1^3 - I_1^3} \\ D_3^1 = \dfrac{X_1^2 \cdot (1-X_3^1) \cdot D \cdot N}{S_1^2 - I_1^2} + \dfrac{(1-X_1^2) \cdot (1-X_3^1) \cdot D \cdot N}{S_1^3 - I_1^3} \\ D_4^1 = \dfrac{X_2^2 \cdot (1-X_4^1) \cdot D \cdot N}{S_2^2 - I_2^2} + \dfrac{(1-X_2^2) \cdot (1-X_4^1) \cdot D \cdot N}{S_1^3 - I_1^3} \\ D_5^1 = \dfrac{X_2^2 \cdot (1-X_5^1) \cdot D \cdot N}{S_2^2 - I_2^2} + \dfrac{(1-X_2^2) \cdot (1-X_5^1) \cdot D \cdot N}{S_1^3 - I_1^3} \\ D_6^1 = \dfrac{X_2^2 \cdot (1-X_6^1) \cdot D \cdot N}{S_2^2 - I_2^2} + \dfrac{(1-X_2^2) \cdot (1-X_6^1) \cdot D \cdot N}{S_1^3 - I_1^3} \\ D_7^1 = \dfrac{X_3^2 \cdot (1-X_7^1) \cdot D \cdot N}{S_3^2 - I_3^2} + \dfrac{(1-X_3^2) \cdot (1-X_7^1) \cdot D \cdot N}{S_1^3 - I_1^3} \\ D_8^1 = \dfrac{X_3^2 \cdot (1-X_8^1) \cdot D \cdot N}{S_3^2 - I_3^2} + \dfrac{(1-X_3^2) \cdot (1-X_8^1) \cdot D \cdot N}{S_1^3 - I_1^3} \end{cases} \quad (5)$$

Where D_1^2, D_2^2, D_3^2 represent the defective rate of semi-finished products 1, 2, and 3 in the unqualified objects, respectively.

$$\begin{cases} D_1^2 = (1-X_1^2) \cdot \dfrac{S_1 - I_1}{S_4 - I_4} \\ D_2^2 = (1-X_2^2) \cdot \dfrac{S_2 - I_2}{S_4 - I_4} \\ D_3^2 = (1-X_3^2) \cdot \dfrac{S_3 - I_3}{S_4 - I_4} \end{cases} \quad (6)$$

The unit price of the i_{th} kind of spare parts is A_i, and its testing cost is P_i^1, and the expected value of each part of the substandard object after dismantling is defined as V , whose meaning is to indicate the economic value of the dismantled spare parts or semi-finished products themselves. The expected value of dismantled parts can be expressed by the following formula:

$$V_i^1 = (A_i + P_i^1) \cdot X_i^1 + A_i \cdot (1-D_i^1) \cdot (1-X_i^1) \quad (7)$$

Where V_i^1 denotes the expected value of 1 spare part i after disassembly and $i \in [1,\ 8]$. If part i has been tested, such as $X_i^1 = 1$, then $V_i^1 = (A_i + P_i^1) \cdot X_i^1$, which includes only the purchase price as well as the cost of its testing. If it has not been tested, $V_i^1 = A_i \cdot (1-D_i^1)$, which represents the expected value of the currently recovered part equal to the unit price at the corresponding authenticity rate. At the same time, the additional profit for each of the three semi-finished products resulting from the dismantling of the substandard finished product can be solved for in the following equation:

$$\begin{cases} V_1^2 = (V_1+V_2+V_3)\cdot X_1^2 + (1-D_9)\cdot(V_1+V_2+V_3+8)\cdot(1-X_1^2) \\ V_2^2 = (V_4+V_5+V_6)\cdot X_2^2 + (1-D_{10})\cdot(V_4+V_5+V_6+8)\cdot(1-X_2^2) \\ V_3^2 = (V_7+V_8)\cdot X_3^2 + (1-D_{11})\cdot(V_7+V_8+8)\cdot(1-X_3^2) \end{cases} \tag{8}$$

Where V_1^2, V_2^2, V_3^2 denote the expected value of semi-finished products 1, 2 and 3 after disassembly of a single finished product, respectively. When the expected value of an object after disassembly > the sum of assembly cost and disassembly cost, the expected value of the spare part is greater than the cost of using it, at which time the corresponding object is disassembled. When $V_1^1+V_2^1+V_3^1 > 8+6$, at this time, the sum of the expected values of the three parts disassembled from semi-finished product 1 is greater than the sum of the assembly cost and the disassembly cost, and $R_1^2=1$, the semi-finished product 1 will be disassembled, and conversely, $R_1^2=0$, the disassembly is not performed.

When $V_4^1+V_5^1+V_6^1 > 8+6$, then the sum of the expected values of the three parts disassembled from semi-finished product 2 is greater than the sum of the assembly cost and the disassembly cost, and $R_2^2=1$, the semi-finished product 2 will be disassembled, and conversely, $R_2^2=0$, the disassembly will not be performed.

When $V_7^1+V_8^1 > 8+6$, when the sum of the expected values of the three parts disassembled from semi-finished product 3 is greater than the sum of the assembly cost and disassembly cost, $R_3^2=1$, semi-finished product 3 will be disassembled, and conversely, $R_3^2=0$, disassembly will not be performed.

When $V_1^2+V_2^2+V_3^2 > 8+10$, then the sum of the expected value of the finished product disassembled from the 3 semi-finished products is greater than the sum of the assembly cost and the disassembly cost, $R_1^3=1$, the finished product will be disassembled, and conversely, $R_1^3=0$, the disassembly will not be performed.

3.3. Analysis of Results and Decisions

Based on the cost-benefit model the following expression can be derived for decision analysis.

(1) Gross income formula

$$P_1 = 200\cdot S_1^3\cdot(1-X_1^3) + 200\cdot I_1^3\cdot X_1^3 \tag{9}$$

Here 200 is the market price of the finished product. If the finished product is tested before it is put on the market, i.e., $X_1^3=1$, then the total revenue is the sales of the genuine product 200 I_1^3. If the finished product is not tested, then the total revenue is the sum of the sales of all finished products 200 S_1^3.

(2) Assembly and Purchase Costs

$$C_1 = (22+22+20)\cdot N + 8\cdot(S_1^2+S_2^2+S_3^2+S_1^3) \tag{10}$$

The first 22 is the sum of the unit prices of parts 1, 2 and 3, the second 22 is the sum of the unit prices of parts 4, 5 and 6, and 20 is the sum of the unit prices of parts 7 and 8. The number of each type of spare part purchased is N, so the cost of spare parts is $(22+22+20)\cdot N$. And the assembly liter costs are all 8, and all semi-finished and finished products need to pay the assembly cost, so the final C_1 is $8\cdot(S_1^2+S_2^2+S_3^2+S_1^3)$.

(3) Testing Costs

$$C_2 = 4\cdot X_1^2\cdot S_1^2 + 4\cdot X_2^2\cdot S_2^2 + 4\cdot X_3^2\cdot S_3^2 + 6\cdot X_1^3\cdot S_1^3 \tag{11}$$

(4) Exchange Losses

$$C_3 = 60 \cdot (S_1^3 - I_1^3) \cdot (1 - X_1^3) \tag{12}$$

Here 60 is the loss incurred for each exchange. If the finished product is tested before it is sold, then $X_1^3 = 1$, so the finished product sold does not contain defective products that will be returned, and the loss on swapping is 0. If the finished product is not tested before it is sold, then $X_1^3 = 0$, and the number of finished products swapped by the user is the number of finished products that do not meet the standard, i.e., $S_1^3 - I_1^3$ and hence C_3 is $60 \cdot (S_1^3 - I_1^3)$.

(5) Dismantling Costs

$$C_4 = 6 \cdot (R_1^2 + R_2^2 + R_3^2) + 10 \cdot R_1^3 \tag{13}$$

Here 6 is the cost of dismantling the semi-finished product and 10 is the cost of dismantling the finished product, and the formula calculates the appropriate costs based on the analyzed dismantling decisions.

(6) Costs Incurred in The Exchange of New Products

$$\begin{aligned} C_5 = {} & (1 - X_1^3) \cdot (S_1^3 - I_1^3) \cdot [22 + 22 + 20 + X_1^1 + X_2^1 + 2 \cdot X_3^1 + X_4^1 + X_5^1 \\ & + 2 \cdot X_6^1 + X_7^1 + 2 \cdot X_8^1 + 4 \cdot (X_1^2 + X_2^2 + X_3^2) + 6 \cdot X_1^3] \end{aligned} \tag{14}$$

If the enterprise is to test the finished products before selling, that is, $X_1^3 = 1$, then all the finished products sold are genuine, and the cost incurred by the exchange of new products is 0. On the other hand, if $X_1^3 = 0$, the enterprise should exchange $S_1^3 - I_1^3$ for the users of the genuine products, and the cost of the purchase of each genuine spare part and the cost of the test are the cost of the individual new product exchange. The cost of purchasing and testing each genuine product is the cost of exchanging a single new product, so the cost of exchanging a new product currently is $(S_1^3 - I_1^3) \cdot (22 + 20 + 20 + X_1^1 + X_2^1 + 2 \cdot X_3^1 + X_4^1 + X_5^1 + 2 \cdot X_6^1 + X_7^1 + 2 \cdot X_8^1 + 4 \cdot (X_1^2 + X_2^2 + X_3^2))$.

(7) Additional Benefits from Dismantling

$$\begin{aligned} P_2 = {} & (V_1^1 + V_2^1 + V_3^1) \cdot R_1^2 + (V_4^1 + V_5^1 + V_6^1) \cdot R_2^2 + (V_7^1 + V_8^1) \cdot R_3^2 \\ & + V_1^2 \cdot R_1^3 \cdot (1 - R_1^2) + V_2^2 \cdot R_1^3 \cdot (1 - R_1^2) \cdot R_2^2 + V_3^2 \cdot R_1^3 \cdot (1 - R_3^2) \end{aligned} \tag{15}$$

The equation begins by selecting the objects to be dismantled based on the dismantling decisions derived from the previous calculations. If the semi-finished product is to be disassembled, the additional benefit obtained is the sum of the expected values of the disassembled spare parts. If the finished product is to be disassembled, the duplicate items should be removed in advance based on the disassembly information of the semi-finished product.

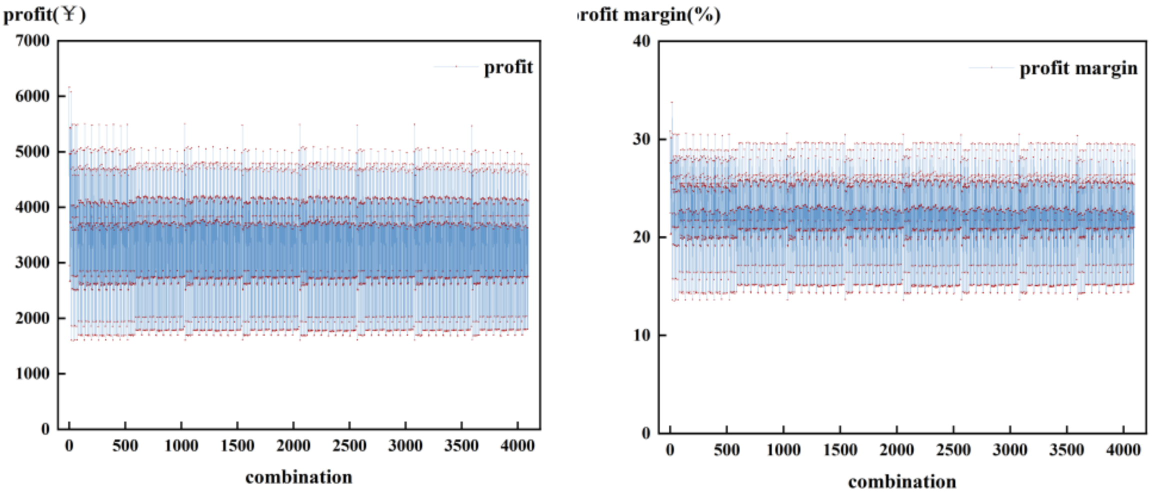
Thus, the total profit P can be derived from the following equation:

$$P = P_1 + P_2 - C_1 - C_2 - C_3 - C_4 - C_5 \tag{16}$$

The profit margin formula can also be obtained:

$$l = \frac{P}{P_1} \tag{17}$$

Since X_i^j is a binary independent variable, there are a total of $2^{12} = 4096$ strategies. Now, assuming $N = 100$, each strategy is analyzed by python using an iterative algorithm, and finally the total profit and profit margin under all decisions are calculated. The results are visualized by means of a dotted line graph, so that Figure 1 can be obtained.



(a) Plot of total profit under different decision combinations (b) Profit margin dot plot under different decision combination

Figure1. Results under different combinations of decisions.

It can be visualized from (a) and (b) in Figure1 that the total profit and profit margin move back and forth in a cycle with a combination number of 500, and the total profit is concentrated in the range of ￥3000 to ￥4000, while the profit margin is concentrated in the range of 20% to 25%. The maximum value of total profit in all results is close to 6000 and the maximum value of profit margin is close to 33%.

And analyze the detailed data can be obtained total profit and profitability into a positive correlation, so the total profit of the largest 10 programs with the highest profitability of the 12 programs is basically the same, the total profit of the smallest 12 programs with the lowest profitability of the 12 programs is basically the same, which combination of the number of 16 decision-making program under the profitability ranked No. 3, but the gap between its total profit rankings orchard, ranked 146th.

Plot the data for the top 12 scenarios and the bottom 12 scenarios for total profit and profitability in a biaxial bar chart Figure 2.

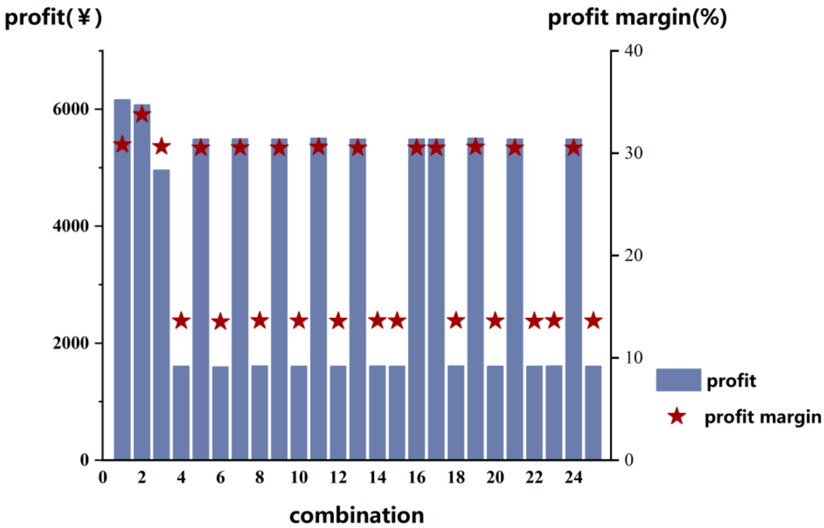


Figure2. A dual-axis column chart based on the top and bottom 12 positions of total profit and profit margin.

The maximum value of Total Profit in this biaxial bar chart is in the case of combination 1, while the maximum value of profit margin is in the case of combination 15, and the rest of the combinations have the same ranking order of the 11 highest and 11 lowest for both indicators.

The total profit and profitability is analyzed comprehensively, in the case of testing only all semi-finished products and dismantling all semi-finished and finished products that are not qualified its profitability is the highest and the total profit is ranked 2nd, and due to the fact that the loss of replacement of unqualified finished products is more expensive and the dismantling of finished products is more expensive than semi-finished products, so in the case of this combination of testing only the 3 semi-finished products and dismantling all the damaged and semi-finished products is beneficial to the company in terms of long term benefits in favor of efficient business development.

4. Conclusion

This article first establishes a sampling test and hypothesis testing model for the decision-making problems faced by enterprises in the production process, and quantitatively estimates the defective rate of purchased spare parts according to the central limit theorem, to lay the foundation for subsequent purchasing decisions. Afterwards, a cost-effectiveness model is established for the purpose of profit maximization, and the decision-making results of testing and disassembling of each component are expressed by binary variables, and all the situations are analyzed by using an ergodic algorithm, and the total profit and profit rate are calculated, which guides the production process of the enterprise.

This model is logically rigorous, fits well with the production reality, and can solve the practical problems well, but the model is too concerned about the quantitative factors, and may ignore the qualitative factors that are not suit- able for quantification but have an important impact on decision-making, such as preference, user evaluation, etc. Therefore, more in-depth research is still needed in this direction in the future.

References

[1] Han, J., Wang, M., & Sun, H. Production and operation decision support system of manufacturing enterprise based on data warehouse [J]. Proceedings of SPIE, 2023, 127020B (6): 127020B-1 - 127020B-6.

[2] Lin, Z., et al. Design of intelligent decision support system for production collaboration in flexible packaging printing enterprises[C]//Innovative Technologies for Printing and Packaging. China Academy of Printing Technology, 2023: 452 - 456.

[3] Wei, W., & Chen, X. Simulation study on production decision of order-type enterprise based on service reliability[C]//Proceedings of 2021 3rd International Conference on System Reliability and Safety Engineering (SRSE). 2021: 237 - 241.

[4] Li, H., Fu, H., Zhao, P., & Fu, A. Optimization decomposition of manufacturing tasks and equipment cycle ordering based on cost control [J]. Thermal Science and Engineering Progress, 2024, 54: 102790.

[5] Liang, H. The role of modern technology in accounting cost calculation of industrial enterprises: Informatization as a key strategy to improve management efficiency[J]. Heliyon, 2025, 11(1): e41523.

[6] Smith, A., & Johnson, B. (2022). *Enhancing Production Decisions through Statistical Sampling and Hypothesis* Testing. Journal of Operations Management, 45(3), 215-228.

[7] Wang, L., & Zhang, Y. (2023). *Hierarchical Cost-Benefit Analysis for Multi-Process Production Systems*. International Journal of Production Economics, 258, 108321.

[8] Tian, B., et al. Analysis of production decision-making evolution of steel enterprises under carbon border adjustment mechanism [J]. HELIYON, 2024, 10(e3338213).

[9] Sun, Y., & Liu, X. Research on the selection of enterprise operating suppliers based on planning algorithms[C]//Proceedings of the Second IYSF Academic Symposium on Artificial Intelligence and Computer Engineering. Xi'an, China, 2021.

[10] Niu, Y. and S. Jin, Decisions on Purchase of Enterprise Emission Rights under the Scenario of Uncertain Emission Right Prices. Industrial Engineering Journal, 2023: p. 77-84, 122.