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# Optimization scheme design in production process based on multi-stage decision-making

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**Abstract:** This paper studies the control of defective rate in the electronic industry chain, designs a small sample binomial distribution sampling detection scheme to verify the supplier 's defective rate statement and optimize the detection cost. Based on the defective rate, the linear programming and dynamic programming / decision tree model are used to optimize the multi-stage production process, including parts inspection, finished product inspection and unqualified product treatment, so as to maximize the profit of the enterprise. A phased optimization strategy is proposed for complex multi-process situations. Finally, according to the sampling test results, the defect rate estimation is adjusted, the problem model is re-optimized, and the cost control reference scheme is provided.

**Keywords:** Sampling detection; Binomial distribution; Hypothesis testing; Optimization problem; Multi-stage decision making.

## 1. Restatement and analysis of the problem

### 1.1. Background and Requirements

In the process of producing best-selling electronic products, an enterprise needs to purchase and assemble two key spare parts (spare parts 1 and spare parts 2). The assembly rules clearly point out that any unqualified parts will lead to unqualified finished products, but double qualification does not guarantee that the finished products are fully qualified. For unqualified finished products, enterprises have two treatment methods: scrapping or dismantling (non-destructive but accompanied by dismantling costs).

### 1.2. Production process decision optimization

**Table 1.** Situations encountered by enterprises in production

| Situation | spare parts 1 | | | spare parts 1 | | | finished products | | | | unqualified finished products | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Defect rate | purchase unit price | detection cost | Defect rate | purchase unit price | detection cost | Defect rate | assembly cost | inspection cost | market price | exchange loss | dismantling cost |
| 1 | 10% | 4 | 2 | 10% | 18 | 3 | 10% | 6 | 3 | 56 | 6 | 5 |
| 2 | 20% | 4 | 2 | 20% | 18 | 3 | 20% | 6 | 3 | 56 | 6 | 5 |
| 3 | 10% | 4 | 2 | 10% | 18 | 3 | 10% | 6 | 3 | 56 | 30 | 5 |
| 4 | 20% | 4 | 1 | 20% | 18 | 1 | 20% | 6 | 2 | 56 | 30 | 5 |
| 5 | 10% | 4 | 8 | 20% | 18 | 1 | 10% | 6 | 2 | 56 | 10 | 5 |
| 6 | 5% | 4 | 2 | 5% | 18 | 3 | 5% | 6 | 3 | 56 | 10 | 40 |

Based on the known defective rate of spare parts and finished products, this study will further explore multiple decision-making problems in the production process of enterprises, including : spare parts detection decision-making : deciding whether to detect spare parts and deal with unqualified products ; finished product inspection decision-making : to evaluate the necessity and treatment of finished product inspection ; disassembly decision of unqualified finished products : analyze the economy of disassembly and subsequent processing flow ; user return and exchange processing : formulate the exchange strategy of user return and exchange, and quantify the relevant losses.

In view of the above decision-making points, we regard it as a decision-making optimization problem [1], and use linear programming method to construct a mathematical model to solve it. In view of the complexity of classification, we first conduct qualitative analysis to initially eliminate schemes that do not meet the optimal criteria and narrow the scope of research. The analysis steps include: qualitative screening, economic analysis, and benefit function model construction. According to different situations (as shown in Table 1), the specific decision-making plan is given, and the decision-making basis and corresponding economic and technical indicators are explained.

## 2. Model building and solving

When constructing this model, we are based on the following core assumptions[2], First, it is assumed that all manufactured finished products can be successfully sold without backlog or unsalable conditions ; secondly, for any unqualified parts, once submitted to the merchant for the return process, the obtained new parts are regarded as fully qualified, no quality hazards ; furthermore, whether it is the recycling process of parts or finished products, the rate of defective products detected remains constant, and does not change with the number of recycling or processing methods ; finally, in the disassembly strategy of the recycled product, [3]we limit the disassembly operation to be performed only once, and for the defective product problem of the customer 's follow-up feedback, the direct replacement rather than the secondary disassembly is adopted to ensure the optimization of efficiency and cost[4].

## 2.1. Model establishment and solution

### 2.1.1. Model preparation

In order to quantify the detection of spare parts and finished products, a state factor is assumed, which is defined as follows:

$$D_i = \begin{cases} 0 \\ 1 \end{cases} \tag{1}$$

Among them, represents the state factor of the spare parts, there are only 0 and 1 states, 0 state means that the spare parts are not detected, 1 state means that the spare parts are detected;

assuming that the number of finished products produced is N, the relationship between the number of parts required and the number of finished products is as follows:

$$N_i = \frac{N}{1-p_i D_i} \tag{2}$$

where $N_i$ denotes the quantity required for a spare part and $p_i$ denotes the defective rate of the spare part;

by calculating the product profit, we can intuitively evaluate various decision-making schemes, that is, the higher the total profit, the better the decision-making scheme. The profit calculation method is as follows:

$$W = A - (1 - D_1) N p_1 d_0 \tag{3}$$

$$A = Na - N_i a_i - D_i b_i N_i - D_1 b_1 N - N c_0 \tag{4}$$

Among them, W said the total profit, A is the finished product profit, asaid each finished price,$D_1$ means the status of the finished product, decide whether to test the finished product, $p_1$ means the defective rate, $d_0$ if the finished product replacement cost, a represents the market price, $a_i$ said the purchase cost of parts, $b_i$ said a parts detection cost, $b_1$means the finished product detection cost, $c_0$ means the assembly cost of finished product;

### 2.1.2. Model establishment

Firstly, the provided table data are observed to identify the abnormal factors that may have a significant impact on the results, so as to determine which factors may have a significant impact on the overall decision-making scheme, and all possible schemes are obtained. The specific division is as follows.

Secondly, the overall decision-making scheme is preliminarily screened, and the obvious non-optimal scheme is excluded. According to the different decisions of the production process, the final profit under different schemes is calculated in combination with Formula ( 2 ) ( 3 ). This calculation process provides the economic index of each scheme, so that we can further screen out those schemes with poor economy, so as to reduce the number of alternatives.

We need to make a second decision on solutions that involve recycling defective products and choosing to disassemble them. In this process, we will repeat the previous steps to further narrow the range of options. After multiple screenings and calculations, we will select those solutions that can bring the highest profits. In order to ensure the implementation of these schemes, we also need to determine the corresponding state factor values, which will help us understand under what conditions these schemes can achieve the best results.

Finally, through this series of analysis and calculation, we will get the optimal decision scheme. This scheme not only considers the production cost, profit and abnormal impact factors, but also takes into account the secondary decision-making of defective product recovery and disassembly, which ensures the scientific, economic and practical decision-making. Such a decision-making scheme will bring the greatest economic benefits to the enterprise.

### 2.1.3. Model solution

Case 1:

The optimal solution: spare parts 1: no detection; spare parts 2: not detected; finished products after assembly: not detected; recycled defective products: disassembly; the average total cost: 24.3198.

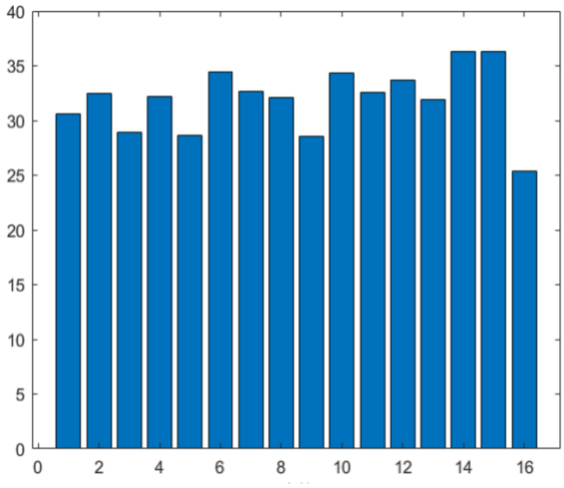


**Figure 1.** Case 1 Cost comparison

Case 2:

The optimal solution: spare parts 1: no detection; spare parts 2: not detected; finished products after assembly: not detected; recycled defective products: disassembly; the average total cost: 22.4712.

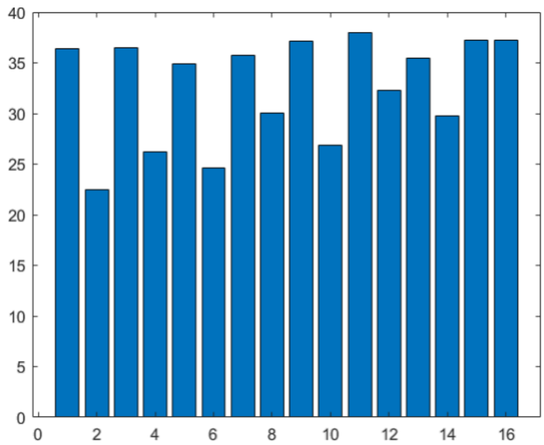


**Figure 2.** Case 2 Cost comparison

Case 3:

The optimal solution: spare parts 1: no detection; spare parts 2: not detected; finished products after assembly: detection; recycled defective products: disassembly; average total cost: 28.0104.

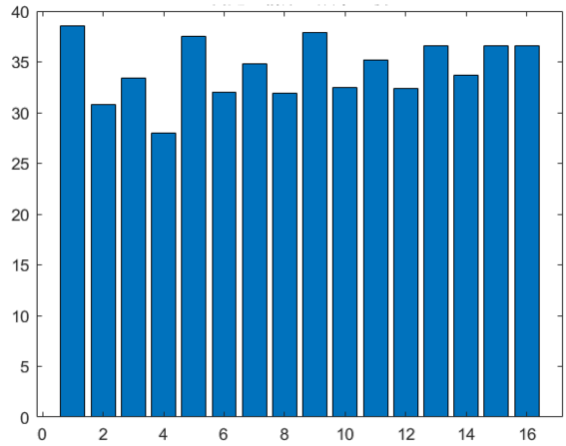


**Figure 3.** Case 3 Cost comparison

Case 4:

The optimal solution: spare parts 1: no detection; spare parts 2: detection; finished products after assembly: detection; recycled defective products: disassembly; the average total cost: 26.53.

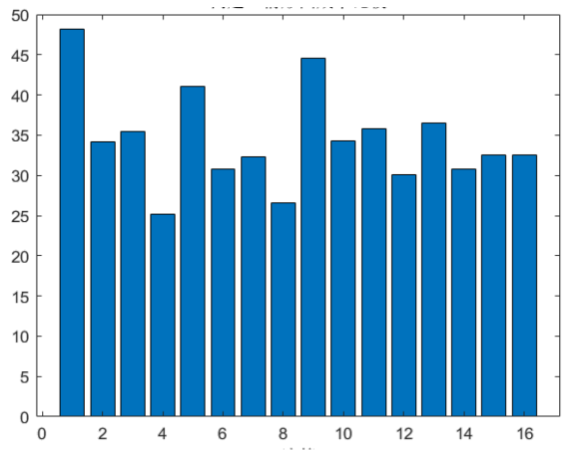


**Figure 4.** Case 4 Cost comparison

# 3. Model evaluation

## 3.1. Advantages

The model is idealized for some situations, so that the model can complete the given tasks well. The analysis and exclusion of some situations simplifies the solution steps, making the solution model simple and easy to understand and practical. At the same time for the solution of the problem, the integrity of the model is strong.

## 3.2. Disadvantages

The idealized treatment of the situation in this model makes a slight gap with the actual situation, but it can be ignored. In addition, due to the large number of parameters in the solution process of the model, the processing ability is weak when multiple parameters are uncertain.

## 3.3. Model promotion

In many cases, it can be adapted to the solution of multi-stage decision-making problems, and the path optimization problem can be solved after adjustment. In solving practical problems, when the given information is sufficient, it can be applied to the decision-making of manufacturing profit or the decision-making of investment in a variety of manufacturing industries.

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