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Decision Analysis Based on Enterprise Production Process

Wu Ning Xi, Jieyi Tan

School of Mathematics and Computer Science, Shaanxi University of Technology, Hanzhong 723000, China

Abstract: This paper mainly studies the decision-making problems encountered by enterprises in the production process, including whether to inspect parts and finished products, and how to handle unqualified parts and finished products. By applying operations research and statistical knowledge, and adopting dynamic programming and one-sided hypothesis testing methods, relevant decision-making problems are effectively solved. In this paper, the authors propose a sampling inspection method to parameterize the defect rate of parts and optimize decision-making schemes for different production stages. Finally, the study analyzes the impact of various decisions on the economic benefits of enterprises, constructs corresponding models using dynamic programming, and derives optimal solutions under various decisions. For the first problem, based on the basic principles of statistics, this paper uses one-sided hypothesis testing to detect whether the defect rate of parts exceeds the nominal value. In the case of a large sample size, the central limit theorem is cleverly applied to approximate the binomial distribution to the normal distribution, thereby simplifying the calculation process. And based on the principle of sampling inspection, detailed judgments are made on whether to accept or reject parts under different confidence levels. When studying the second problem, this paper cleverly adopts the dynamic programming method to conduct detailed decision analysis on the three key stages of the enterprise production process: part inspection, finished product inspection, and unqualified product handling. And through the reverse analysis method, starting from the final product, the decision-making of each stage is gradually optimized to ensure that the risk is minimized while controlling costs. By evaluating the relationship between inspection costs and potential losses, as well as the specific impact of different handling methods for unqualified products on the economic benefits of enterprises, the goal is to maximize economic benefits while ensuring product quality. The third problem further enhances the complexity of decision-making based on the second problem, considering multiple processes and multiple parts to optimize decision-making in the multi-stage production process. This problem still adopts the reverse analysis method of dynamic programming to construct a more complex dynamic programming model, comprehensively considering the inspection costs, unqualified product handling costs, and potential market risks of each production stage. In the process of model construction, in-depth analysis is conducted on how to effectively handle parts, semi-finished products, unqualified semi-finished products, finished products, and unqualified finished products at different production stages, including different decisions for each stage. Through careful analysis, it provides enterprises with an optimal decision-making scheme for multiple processes and multiple parts.

Keywords: Sampling inspection; Central limit theorem; Dynamic programming; Optimal decision-making scheme; Reverse analysis

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1. Restatement of the problem

1.1. Background

A company produces an electronic product that requires two types of components (Component 1 and Component 2) for assembly. During the assembly process, if any of the components are defective, the final product will be defective. Even if both components are qualified, the final product may still be defective due to assembly issues. For defective products, the company can choose to scrap them or dismantle them. Dismantling does not damage the components, but it will incur dismantling costs. A corresponding model and algorithm to answer the following questions is established.

1.2. Problems to be solved

Problem 1: Suppliers claim that the defect rate of a batch of components will not exceed a certain nominal value (e.g., 10%). The company needs to design a sampling inspection plan to decide whether to accept this batch of components. The plan should satisfy the following two conditions:

(1) With 95% confidence, if the defect rate of components exceeds the nominal value, reject the batch.

(2) With 90% confidence, if the defect rate of components does not exceed the nominal value, accept the batch.

Problem 2: Given the defect rates of two types of components and the final product, the company needs to make decisions for each stage of the production process:

(1) Whether to inspect the components and how to handle defective components.

(2) Whether to inspect the assembled products and how to handle defective products.

(3) For defective products purchased by customers, the company will unconditionally replace them, incurring certain replacement losses. Provide a specific decision plan and give reasons.

Problem 3: Repeat the decision-making process of Problem 2 for multi-step processes and multiple components, and provide a specific decision plan.

2. Analysis of the problem

2.1. Analysis of Problem 1

According to the problem description, the study needs to detect whether the defect rate of a certain batch of sample components exceeds a certain standard value, i.e., whether the actual value significantly deviates from the standard value. This problem has already clearly given the standard value of the defect rate. To make a rejection (acceptance) decision (if the defect rate significantly exceeds the standard value, reject this batch of components; otherwise, accept them), the authors only need to consider whether the sample components exceed the standard value, which fits the unilateral hypothesis testing situation. Therefore, the authors adopt unilateral hypothesis testing. There will be some defective products in this batch of samples, and the test results should conform to a binomial distribution. However, in reality, the sample size can be infinitely large, so the authors use a normal distribution to approximate the binomial distribution. This approximation allows the authors to use the properties of the normal distribution for hypothesis testing, thus simplifying the calculation by using Z-testing.

2.2. Analysis of Problem 2

Based on the problem description, the authors need to find the optimal solution according to different decisions made at various stages. This problem can be divided into three stages: processing of parts, processing of finished products, and handling of products that enter the market or are detected as defective. Firstly, the authors analyze the cost of inspecting parts and the consequences of not inspecting them before proceeding to the next step to determine whether to inspect the parts. Secondly, if the parts are qualified or not inspected, the authors determine whether to inspect the finished products based on the cost of inspection and the consequences of not detecting defects before they enter the market. Finally, for unqualified finished products, the authors decide whether to discard or dismantle them by analyzing the dismantling cost and the loss incurred by choosing to discard them. The authors need to use dynamic programming to construct a profit maximization model based on whether to inspect parts and how to handle unqualified products. It is important to note that starting from the third stage allows the authors to more naturally utilize known information, and it is simpler to consider the third stage as the initial stage. Therefore, the authors adopt reverse processing to solve this problem.

2.3. Analysis of Problem 3

Problem 3 is a multi-objective decision-making problem that can be seen as an extension of Problem 2. Problem 3 transforms the two parts and two processes in Problem 2 into m parts and n processes. The authors need to find the optimal solution based on different decisions made at various stages, so the authors still consider using dynamic programming to solve this problem. Unlike Problem 2, Problem 3 involves multiple processes, resulting in multiple semi-finished products. The authors also need to analyze the cost of inspecting semi-finished products and the outcomes of not inspecting them before proceeding to the next step to determine whether to inspect the semi-finished products.

3. Model assumptions

(1) It is assumed that the defect rate of parts provided by suppliers does not exceed the specified limit and is truthful and credible.

(2) It is assumed that the enterprise only considers costs and profits when making decisions, without considering other factors.

(3) It is assumed that multiple processes in the production of the enterprise are independent and do not affect each other.

4. Symbol description

The symbol description is shown in **Table 1**.

Table 1. Symbol description

Symbol	Meaning
C_c	Cost of disassembling non-conforming finished products
C_m	Cost of Part 1 and Part 2
C_n	Cost of assembling finished products
C_d	Loss from replacing non-conforming finished products
C_j	Cost of inspecting finished products
C_q	Market price of finished products

Table 1 (Continued)

Symbol	Meaning
C_c	Cost of disassembling non-conforming finished products (Repeated)
C_1	Cost of inspecting Part 1
C_2	Cost of inspecting Part 2
C_{12}	Cost of inspecting Part 1 and Part 2
P_1	Defect rate of Part 1
P_2	Defect rate of Part 2
C_{m123}	Cost of semi-finished product 1, semi-finished product 2, and semi-finished product 3
C_{j123}	Cost of inspecting semi-finished product 1, semi-finished product 2, and semi-finished product 3
C_{ji}	Cost of inspecting various semi-finished products
C_{Ci}	Cost of dismantling various semi-finished products
C_{li}	Cost of dismantling various parts

5. Model establishment and solution

5.1. Establishment and solution of the model for Problem 1

5.1.1. Model assumptions

For Problem 1, the authors need to test whether the defect rate P of a batch of parts exceeds the standard value p_0. The authors adopt a one-sided hypothesis test. The hypotheses are constructed as follows:

Null Hypothesis H_0: The defect rate $p \leq p_0$.

Alternative Hypothesis H_1: The defect rate $p \geq p_0$.

The test results should follow a binomial distribution, assuming X is the number of defects drawn, n is the sample size, and p is the probability of drawing a defect. That is, the random variable X follows a binomial distribution with parameters n and p, denoted as $X \sim B(n,p)$.

Under the hypothesis H_0, the probability of a defect is given by:

$$P(X = k) = \binom{n}{k} p^k (1 - k)^{n-k}$$

where $\binom{n}{k}$ is the combination number representing the probability of drawing k defects from n samples.

However, as the sample size approaches infinity, the authors need to approximate the binomial distribution using a normal distribution. For a binomial distribution $B(n,p)$, when n is large, the authors use the Central Limit Theorem to approximate its distribution. Specifically, if $X \sim B(n,p)$, then the mean and variance of X are np(μ=np) and np(1-p)(σ^2=np(1-p)), respectively. When n is large, the distribution of X can be approximated as:

$$Z = \frac{X - np}{np(1 - p)} \sim N(0,1)$$

This implies that the random variable X from the binomial distribution can be transformed into a standard normal random variable Z through standardization. The authors know that when the sample size n is sufficiently large, the shape of the binomial distribution approaches a normal distribution due to the Central Limit Theorem. This approximation allows the authors to perform hypothesis testing, especially the z-test, using the properties of the normal distribution, thereby simplifying the calculation process.

5.1.2. Parameter determination

Nominal defect rate: $p_0 = 10\%$

Sample size: n (to be determined)

Significance level: α (for 95% confidence, α=5%; for 90% confidence, α=0.10)

5.1.3. Sample size calculation

Based on the normal approximation of the binomial distribution, the sample size can be approximately calculated using the following formula:

$$n = \left(\frac{Z_{\alpha/2}\sqrt{p_0(1-p_0)} + Z_\beta\sqrt{p(1-p)}}{p_0 - p} \right)^2$$

Where $Z_{\alpha/2}$ is the critical value of the standard normal distribution;

For 95% confidence, $Z_{0.025} \approx 1.96$;

For 90% confidence, $Z_{0.05} \approx 1.645$.

Z_β is the z-value corresponding to the power (1-β);

For 95% confidence, $Z_{0.95} \approx 1.645$;

For 90% confidence, $Z_{0.90} \approx 1.28$.

p is the maximum acceptable defect rate, usually slightly lower than p_0, assuming $p = 0.05$(5%).

For 95% confidence, with $p_0 = 0.1$ (nominal defect rate) and $p = 0.05$ (maximum acceptable defect rate), $Z_{\alpha/2} = Z_{0.025} \approx 1.96$, $Z_\beta = Z_{0.05} \approx 1.645$, the authors can calculate the sample size:

$$n = \left(\frac{1.96 \times \sqrt{0.1 \times (1-0.1)} + 1.645 \times \sqrt{0.05 \times (1-0.05)}}{0.1 - 0.05} \right)^2 \approx 356.47$$

Rounding up gives n=357.

For 90% confidence, with $p_0 = 0.1$(nominal defect rate) and $p = 0.05$ (maximum acceptable defect rate), $Z_{\alpha/2} = Z_{0.05} \approx 1.645$, $Z_\beta = Z_{0.10} \approx 1.28$, the authors can calculate the sample size:

$$n = \left(\frac{1.645 \times \sqrt{0.1 \times (1-0.1)} + 1.28 \times \sqrt{0.05 \times (1-0.05)}}{0.1 - 0.05} \right)^2 \approx 241.33$$

Rounding up gives n=242.

5.1.4. Derived sample size

(1) At 95% confidence, if the defect rate is 10%, then 357 parts should be inspected.

(2) At 90% confidence, if the defect rate is 10%, then 242 parts should be inspected.

5.1.5. Specific results

Through the above steps, the authors can determine the number of samples for sampling inspection, but for specific results of defects under different confidence levels, the authors can calculate using the following formulas:

$$k = np_0 + Z_\alpha\sqrt{np_0(1-p_0)}$$

For 95% confidence, $Z_\alpha = Z_{0.05} \approx 1.645$

Then $k = 357 \times 0.1 + 1.645 \times \sqrt{357 \times 0.1 \times (1-0.1)} \approx 45.02$

Rounding up gives $k = 45$.

For 90% confidence, $Z_{\alpha} = Z_{0.10} \approx 1.28$

Then $k = 242 \times 0.1 + 1.28 \times \sqrt{242 \times 0.1 \times (1 - 0.1)} \approx 30.17$

Rounding up gives $k = 30$.

Based on these calculations, at a 95% confidence level, if among 357 parts, the number of defects exceeds 45, there is sufficient evidence to reject the batch due to a defect rate exceeding the nominal 10%.

At a 90% confidence level, if among 242 parts, the number of defects does not exceed 30, there is sufficient evidence to accept the batch as the defect rate does not exceed the nominal 10%.

5.2. Modeling and solution for Problem 2

5.2.1. Scenario analysis

For Problem 2, the authors need to make decisions at various stages to find the optimal solution. Based on the stages of the enterprise's production process, the authors have created a stage analysis diagram as shown in **Figure 1**.

According to the flowchart, the authors divide the decision-making process into three stages: processing of parts, processing of finished products, and handling of finished products that enter the market or are detected as non-conforming.

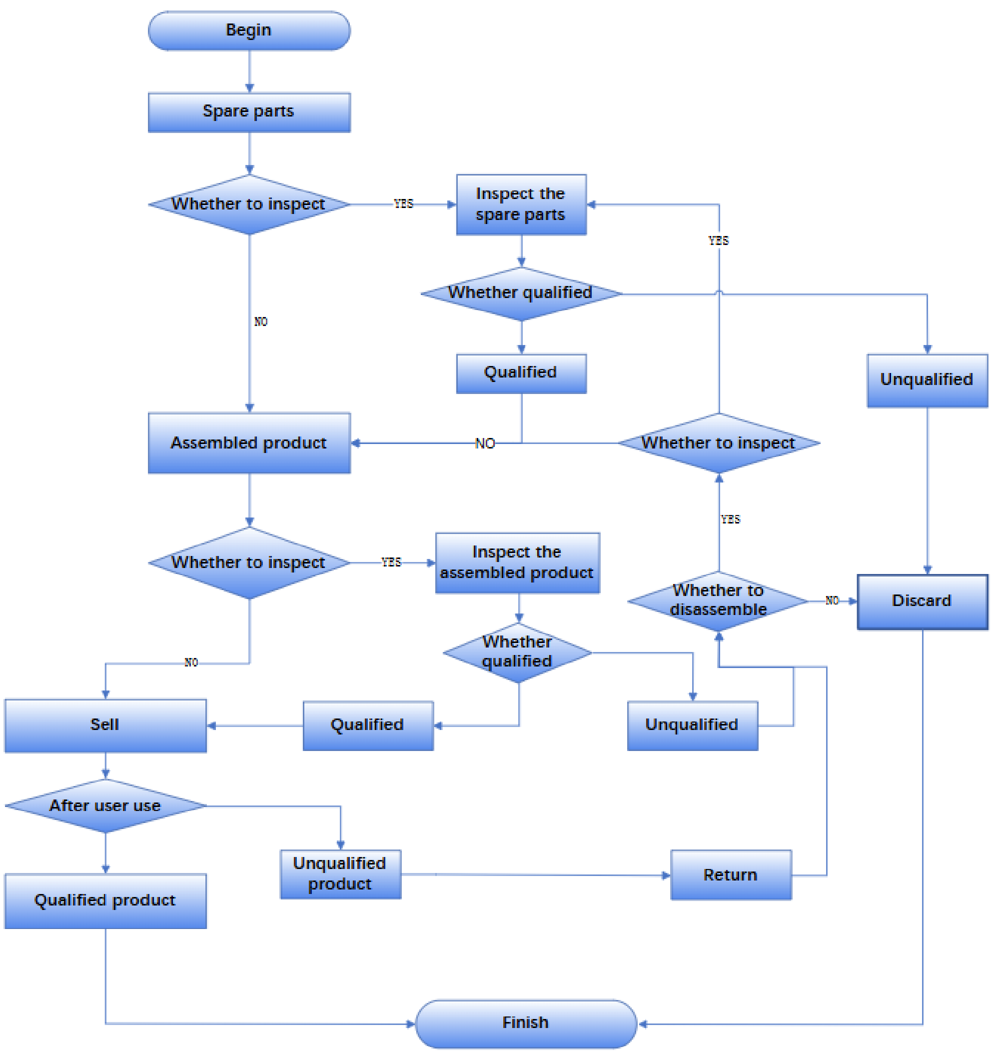

Figure 1. Inspection flowchart

5.2.2. Problem decision-making

In the production process, there are four operable objects: Part 1, Part 2, Finished Product, and Non-conforming Finished Product. Each object has two operations (whether to inspect and whether to dismantle non-conforming finished products).

a. Processing of parts

There are two types of parts in this problem: Part 1 and Part 2. Each part has two operations to choose from. Therefore, there are a total of 4 decisions for the processing of parts.

b. Processing of finished products

For finished products, there are two operations to choose from. Thus, there are 2 decisions for the processing of finished products.

c. Handling of non-conforming finished products

For non-conforming finished products, there are two options (discard or dismantle). Hence, there are 2 decisions for handling non-conforming finished products.

d. Total number of decisions

Combining the above, there are $2^2 \times 2 \times 2 = 16$ various decision methods (**Table 2**).

Table 2. Decision table for parts, semi-finished products, and finished products

Decision	Inspect Part 1?	Inspect Part 2?	Inspect finished product?	Action for non-conforming product
Decision 1	Yes	Yes	Yes	Disassemble
Decision 2	Yes	Yes	Yes	Discard
Decision 3	Yes	Yes	No	Disassemble
Decision 4	Yes	Yes	No	Discard
Decision 5	Yes	No	Yes	Disassemble
Decision 6	Yes	No	Yes	Discard
Decision 7	Yes	No	No	Disassemble
Decision 8	Yes	No	No	Discard
Decision 9	No	Yes	Yes	Disassemble
Decision 10	No	Yes	Yes	Discard
Decision 11	No	Yes	No	Disassemble
Decision 12	No	Yes	No	Discard
Decision 13	No	No	Yes	Disassemble
Decision 14	No	No	Yes	Discard
Decision 15	No	No	No	Disassemble
Decision 16	No	No	No	Discard

5.2.3. Model establishment

To derive the optimal solution (i.e., maximizing profits), it is more natural and simpler to start from the third stage, utilizing known information and considering it as the initial state. Therefore, the authors adopt a reverse approach, progressing from the third stage to the second, and then to the first.

a. Stage 3: Disposal of defective finished products

For identified defective finished products, the authors have the option to discard or dismantle them. If dismantled, components can be recovered, but dismantling costs will arise.

(1) Discard defective finished products

$$F_{31} = 0$$

(2) Dismantle defective finished products

$$F_{32} = C_c + C_m \times (1-P_1) \times (1-P_2) + C_{12}$$

Where: F_{31} represents the cost of discarding defective finished products;

F_{32} represents the total cost of dismantling defective finished products;

C_c represents the cost of dismantling defective finished products;

C_m represents the cost of Component 1 and Component 2;

P_1 represents the defect rate of Component 1;

P_1 represents the defect rate of Component 2;

C_{12} represents the cost of inspecting Component 1 and Component 2.

b. Stage 2: Processing of finished products

After the assembly of finished products, the authors can choose to sell them directly or conduct inspections. Direct sales may lead to defective products entering the market, resulting in replacement losses. Inspection incurs additional costs but prevents defective products from entering the market.

(1) Direct Sales

$$F_{21} = C_n + C_d \times (1-(1-P_1) \times (1-P_2)) + F_3$$

(2) Finished Product Inspection

$$F_{22} = C_j + C_q \times (1-(1-P_1) \times (1-P_2)) + F_3$$

Where: F_{21} represents the cost of direct product sales; F_{22} represents the total cost of finished product inspection; C_n represents the cost of assembling finished products; C_d represents the replacement loss for defective finished products; C_j represents the cost of inspecting finished products; C_q represents the market price of finished products; F_3 represents the optimal decision from Stage 3.

c. Stage 1: Processing of components

For Component 1 and Component 2, the authors have two options: inspect or not inspect. If not inspected, components directly enter the assembly process. Inspection identifies and discards defective components, incurring inspection costs.

(1) No inspection for Component 1 and Component 2

$$F_{11} = F_2$$

(2) Inspection for Component 1, no inspection for Component 2

$$F_{12} = C_1 + F_2$$

(3) Inspection for Component 2, no inspection for Component 1

$$F_{13} = C_2 + F_2$$

(4) Inspection for both Component 1 and Component 2

$$F_{14} = C_{12} + F_2$$

Where: F_{11} represents the total cost without inspection for both components;

F_{12} represents the total cost with inspection for Component 1 and no inspection for Component 2;

F_{13} represents the total cost with inspection for Component 2 and no inspection for Component 1;

F_{14} represents the total cost with inspection for both components;

F_2 represents the optimal decision from Stage 2;

C_1 represents the cost of inspecting Component 1;

C_2 represents the cost of inspecting Component 2.

d. Objective function establishment

Based on these three stages, the authors can establish the objective function:

$$\text{Max } Z = \max(F_{11}, F_{12}, F_{13}, F_{14})$$

5.2.4 Specific Results

Through model assumptions and code implementation, the authors can obtain the optimal decision solutions for the following six scenarios (**Table 3**).

Table 3. Optimal decision solutions for six different scenarios

Scenario	Inspect Part 1?	Inspect Part 2?	Inspect finished product?	Action for non-conforming product	Profit
Scenario 1	Yes	Yes	Yes	Disassemble	42.5
Scenario 2	Yes	Yes	Yes	Disassemble	43.0
Scenario 3	Yes	Yes	Yes	Disassemble	42.5
Scenario 4	Yes	Yes	Yes	Disassemble	47.0
Scenario 5	No	Yes	Yes	Disassemble	41.9
Scenario 6	Yes	No	Yes	Disassemble	44.2

The results show that in all scenarios, unqualified finished products are chosen to be dismantled, indicating that the benefits of dismantling exceed the dismantling costs. Simultaneously, most scenarios opt for inspection of parts and finished products, likely because inspection reduces the risks associated with unqualified products.

5.3. Model establishment and solution for Problem 3

5.3.1. Scenario analysis

Problem 3 is a multi-objective decision-making problem, requiring the authors to make decisions at various stages to obtain the optimal decision plan [1–5]. Based on the stages in this problem, the authors have created a flowchart (**Figure 2**) to facilitate problem-solving.

Problem 3 involves multiple processes and parts, essentially an extension of Problem 2. According to the flowchart, the authors divide this problem into four stages: processing of parts, processing of semi-finished products, processing of finished products, and handling of unqualified finished products that enter the market or are detected.

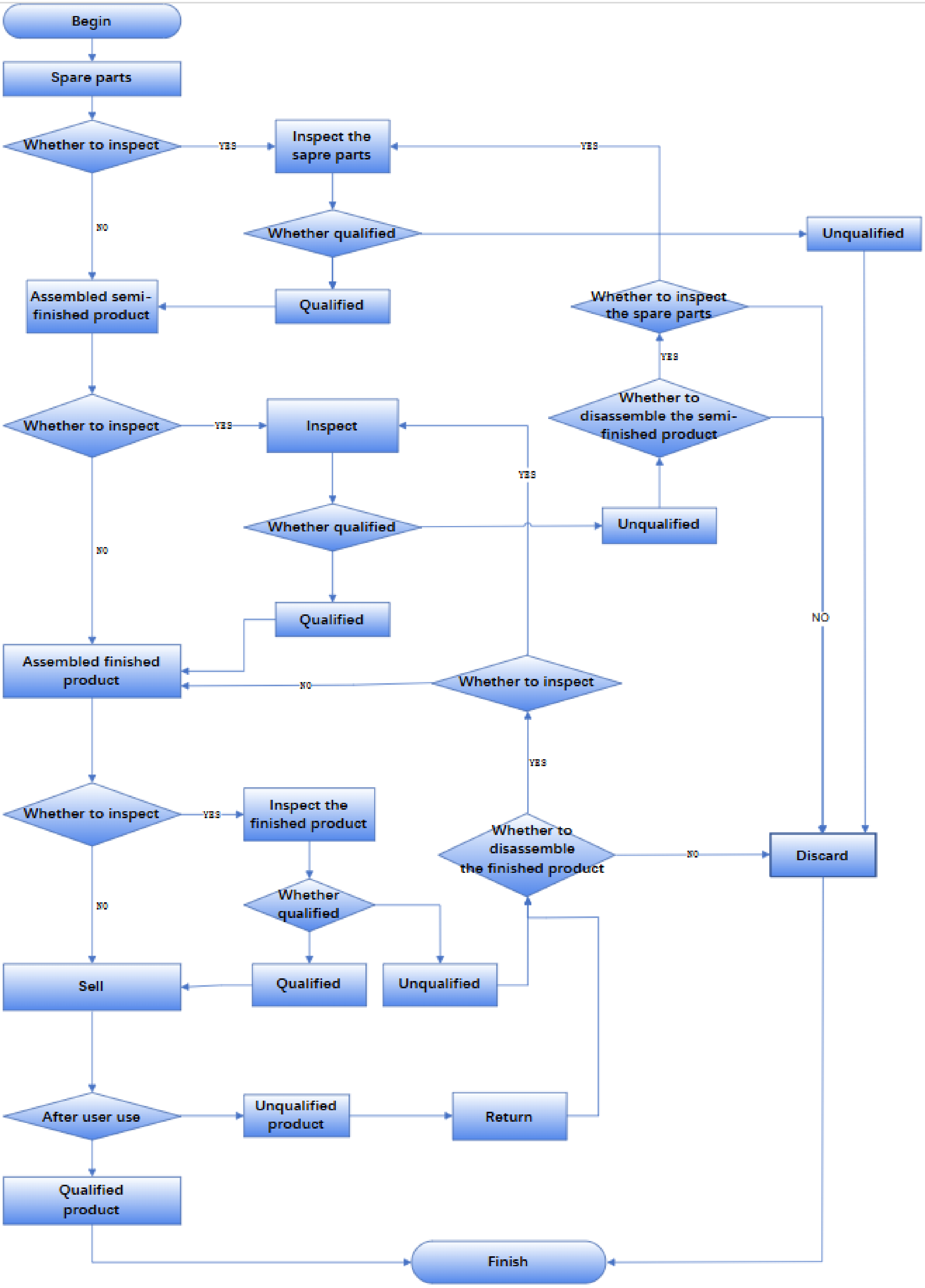

Figure 2. Multi-objective decision-making flowchart

5.3.2. Problem decision-making

In the production process, there are fifteen operable objects: Part 1, Part 2, Part 3, Part 4, Part 5, Part 6, Part 7, Part 8, Semi-finished Product 1, Semi-finished Product 2, Semi-finished Product 3, Finished Product, Unqualified Semi-finished Product 1, Unqualified Semi-finished Product 2, Unqualified Semi-finished Product 3, and Unqualified Finished Product. Each object has two operations (whether to inspect and whether to dismantle unqualified products).

a. Processing of parts

There are eight types of parts in this problem: Part 1 through Part 8. Each part has two options for operation. Therefore, there are a total of 256 decision combinations for part processing.

b. Processing of semi-finished products

For semi-finished products, there are two operations to choose from. Consequently, there are several decision combinations for semi-finished product processing. (Note: The exact number is not provided in the original text and should be calculated based on the context.)

c. Processing of unqualified semi-finished products

For unqualified semi-finished products, there are two choices (discard or dismantle). Hence, there are several decision combinations for unqualified semi-finished product processing. (Note: The exact number is not specified in the original text and depends on the number of unqualified semi-finished products.)

d. Processing of finished products

For finished products, there are two operations to select from. Therefore, there are two decision combinations for finished product processing.

e. Processing of unqualified finished products

Regarding unqualified finished products, there are two options (discard or dismantle). As a result, there are two decision combinations for unqualified finished product processing.

f. Total number of decision combinations

Combining the above elements, there are a total of 32,768 different decision methods.

5.3.3. Model establishment

To obtain the optimal solution (i.e., maximizing profits), it is simpler to consider the final stage (Stage 4) as the initial state. Therefore, the authors adopt reverse dynamic programming, working backward from the final stage.

a. Stage 4: Handling of defective finished products

For defective finished products detected, the authors have the option to discard them or dismantle them. If dismantled, the authors can recover the corresponding semi-finished products, but there will be dismantling costs.

(1) Discard defective finished products

$$F_{41} = 0$$

(2) Dismantle defective finished products

$$F_{42} = C_c + C_{m123} + C_{j123}$$

Where, F_{41}: Cost of discarding defective finished products

F_{42}: Total cost of dismantling defective finished products

C_c: Cost of dismantling a single defective finished product

C_{m123}: Cost of semi-finished products 1, 2, and 3

C_{j123}: Cost of inspecting semi-finished products 1, 2, and 3

b. Stage 3: Handling of finished products

After assembly of finished products, the authors can choose to sell them directly or inspect them.

Selling directly may result in defective products entering the market, leading to replacement losses. Inspection incurs a cost but prevents defective products from entering the market.

(1) Direct sale

$$F_{31} = C_n + C_d + F_4$$

(2) Inspection of finished products

$$F_{32} = C_j + C_q + F_4$$

Where, F_{31}: Cost of direct sale of finished products

F_{32}: Total cost of inspecting finished products

C_n: Assembly cost of finished products

C_d: Replacement loss for defective finished products

C_j: Cost of inspecting finished products

C_q: Market price of finished products

F_4: Optimal decision from Stage 4

c. Stage 2: Handling of semi-finished products

For semi-finished products, the authors have two options: inspect or not inspect. If not inspected, they go directly to assembly. If inspected, and a defective semi-finished product is found, the authors can choose to discard or dismantle it. Dismantling recovers corresponding parts but incurs dismantling costs.

(1) Do not test Intermediate Product 1, Intermediate Product 2, or Intermediate Product 3.

$$F_{21} = F_3$$

(2) Test Intermediate Product 1, but do not test Intermediate Product 2 or Intermediate Product 3.

$$F_{22} = C_{j1} + C_{c1} + C_{l123} + F_3$$

(3) Test Intermediate Product 2, but do not test Intermediate Product 1 or Intermediate Product 3.

$$F_{23} = C_{j2} + C_{c21} + C_{l456} + F_3$$

(4) Test Intermediate Product 3, but do not test Intermediate Product 1 or Intermediate Product 2.

$$F_{24} = C_{j3} + C_{c3} + C_{l86} + F_3$$

(5) Test Intermediate Product 1 and Intermediate Product 2, but do not test Intermediate Product 3.

$$F_{25} = C_{j12} + C_{c12} + C_{l123456} + F_3$$

(6) Test Intermediate Product 1 and Intermediate Product 3, but do not test Intermediate Product 2.

$$F_{26} = C_{j13} + C_{c13} + C_{l12378} + F_3$$

(7) Test Intermediate Product 2 and Intermediate Product 3, but do not test Intermediate Product 1.

$$F_{27} = C_{j23} + C_{c3} + C_{l45678} + F_3$$

(8) Test Intermediate Product 1, Intermediate Product 2, and Intermediate Product 3.

$$F_{28} = C_{j123} + C_{c123} + C_{l12345678} + F_3$$

Where, F_{2i}: Total cost for different decisions on semi-finished products ($i \in (1,8)$)

F_{ji}: Cost of inspecting different semi-finished products ($i \in \{1,2,3,12,13,23,123\}$)

C_{Ci}: Cost of dismantling different semi-finished products ($i \in \{1,2,3,12,13,23,123\}$)

C_{li}: Cost of dismantling different parts ($i \in \{123,456,78,123456,12378,45678,12345678\}$)

F_3: Optimal decision from Stage 3

d. Stage 1: Handling of parts

There are eight types of parts, and each part has two possible actions. Thus, there are =256 possible decisions for handling parts.

$$F_{1i} = C_{li} + C_{li}$$

Where, F_{1i}: Total cost for different decisions on parts inspection ($i \in (1,8)$)

C_{li}: Cost of inspecting different parts ($i \in (1,8)$)

C_{li}: Optimal decision from Stage 2

e. Establishment of the objective function

Based on these four stages, we can establish the objective function:

Max Z = max(F_{1i}), $i \in (1,8)$.

5.3.4. Specific results

The results are shown in **Tables 4** and **5**.

Table 4. Inspection table for accessories, semi-finished products, and finished products

Parts, semi-finished products & finished products	Inspect?
Part 1	Yes
Part 2	Yes
Part 3	Yes
Part 4	Yes
Part 5	Yes
Part 6	Yes
Part 7	Yes
Part 8	Yes
Semi-finished Product 1	No
Semi-finished Product 2	No
Semi-finished Product 3	No
Finished Product	Yes

Table 5. Disassembly table for non-conforming semi-finished products and finished products

Non-conforming Semi-finished/Finished products	Disassemble?
Semi-finished Product 1	No
Semi-finished Product 2	No
Semi-finished Product 3	No
Finished Product	No

Through model assumptions and code implementation, the authors can obtain the optimal solution for decision-making on this problem: inspect all accessories, do not inspect semi-finished products, inspect finished products, and do not disassemble non-conforming semi-finished products and finished products. The maximum profit that can be obtained is 150.0.

6. Conclusion

6.1. Advantages of the model

(1) The model handles each problem in stages, systematically analyzing the decision-making process from accessories to the final product, ensuring that every process is considered.

(2) Through inspection and disassembly decisions, the model can effectively control costs and risks.

(3) The model adopts reverse processing, starting from the finished product, which more naturally utilizes known information and makes it easier to correlate decisions with final profits.

(4) The model can be extended to more production stages and decision variables, adapting to more complex production processes.

(5) The model can adjust decisions based on different production scenarios, making it applicable to a variety of decision-making problems.

6.2. Disadvantages of the model

(1) The effectiveness of the model highly depends on accurate defect rates and cost data. Any inaccurate data may affect decision variables.

(2) For large-scale problems, resource consumption is high, and the model requires significant computational resources and data to find the optimal solution.

(3) The model is not flexible enough in handling non-preprocessing situations, limiting its ability to respond to unexpected situations.

(4) The complexity of the model makes it relatively difficult to implement when involving multiple decision variables and stages.

Disclosure statement

The authors declare no conflict of interest.

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