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MARKETING RESEARCH & ANALYTICS

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Series 1: Foundations of Marketing Decision Analysis

Series outline

- **Part 1.1 Elements of Decision Analysis**
  - 1.1.1 Meaning and scope of decision analysis
  - 1.1.2 Types of decision situations
  - 1.1.3 Decision trees and their applications
- **Part 1.2 Systems and System Analysis in Marketing Decisions**
  - 1.2.1 Concept of systems in marketing
  - 1.2.2 System analysis for decision-making
  - 1.2.3 Interrelationships between marketing subsystems
- **Part 1.3 Operational Research Foundations for Decision Analysis**
  - 1.3.1 Principles of operational research (OR)
  - 1.3.2 OR approaches to marketing decision problems
  - 1.3.3 Case illustrations of OR in marketing
- **Part 1.4 Introduction to Modelling and Simulation**
  - 1.4.1 Role of modelling in OR
  - 1.4.2 Simulation techniques for marketing decisions
  - 1.4.3 Practical applications and limitations

Introduction

Decision-making is at the heart of every marketing activity. Whether a manager is choosing between alternative promotional strategies, allocating resources to different markets, or forecasting demand, the ability to analyse decisions systematically is vital. This Series introduces you to the foundations of marketing decision analysis, providing you with the tools and perspectives needed to approach complex business problems with clarity and confidence.

The aim of this Series is to equip you with the knowledge and skills to define, analyse, and apply decision analysis techniques in marketing contexts. By the end, you will be able to interpret decision situations, evaluate systems, and apply operational research methods to practical marketing problems.

We shall commence this Series by exploring the elements of decision analysis, including the meaning, scope, and types of decision situations, as well as decision trees. Next, we will examine systems and system analysis, focusing on how marketing decisions are influenced by interconnected subsystems. Following that, we will move on to operational research foundations, where you will learn how OR approaches can be applied to marketing decision problems. Finally, we will wrap up by introducing modelling and simulation, highlighting their role in analysing marketing scenarios and their practical applications.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **2.1** define the elements and scope of decision analysis in marketing contexts,

- **2.2** explain different types of decision situations and construct decision trees,
- **2.3** analyse systems and conduct system analysis for marketing decision-making,
- **2.4** evaluate operational research approaches applied to marketing problems, and
- **2.5** demonstrate how modelling and simulation techniques can be applied to marketing decision scenarios.

1.1 Elements of Decision Analysis

1.1.1 Meaning and scope of decision analysis

Decision analysis refers to a structured approach for making choices among alternatives when outcomes are uncertain. It provides a framework that combines logical reasoning with quantitative tools to guide managers in selecting the most appropriate course of action. In marketing, decision analysis helps managers evaluate strategies such as pricing, product launches, or promotional campaigns by considering both risks and potential rewards.

The scope of decision analysis extends beyond simple choices. It encompasses identifying decision problems, structuring them into models, evaluating alternatives, and recommending solutions. By applying decision analysis, marketing managers can reduce uncertainty and improve the quality of their decisions.

Fill in the blank: Decision analysis provides a structured framework for making choices when _____ are uncertain.

1.1.2 Types of decision situations

A **decision situation** is the context in which a choice must be made. Decision situations can be classified into three broad categories:

- **Decision under certainty**: The outcomes of each alternative are known with certainty. For example, choosing a supplier with fixed prices and guaranteed delivery.
- **Decision under risk**: The outcomes are not certain, but probabilities can be assigned. For instance, launching a new product where market demand is estimated with probability distributions.
- **Decision under uncertainty**: Neither outcomes nor probabilities are known. This often occurs in highly dynamic markets where consumer behaviour is unpredictable.

Fill in the blank: When probabilities can be assigned to outcomes, the situation is described as decision under _____.

1.1.3 Decision trees and their applications

A **decision tree** is a graphical representation of decision problems that shows alternatives, possible outcomes, and associated probabilities. It helps managers visualise complex decision scenarios and evaluate expected values of different strategies.

In marketing, decision trees are often used for product launch decisions, advertising strategies, or market entry analysis. By mapping out possible outcomes, managers can calculate expected profits or losses and select the most rational option.

Fill in the blank: A decision tree is a _____ representation of decision problems that shows alternatives and outcomes.

Pilot questions 1.1

1. Which term refers to a structured approach for making choices among alternatives when outcomes are uncertain?
2. What are the three categories of decision situations?
3. In which type of decision situation can probabilities be assigned to outcomes?
4. What graphical tool is used to represent decision problems with alternatives and outcomes?
5. Give one example of how decision trees can be applied in marketing.

1.2 Systems and System Analysis in Marketing Decisions

1.2.1 Concept of systems in marketing

A **system** is a set of interrelated components that work together to achieve a common goal. In marketing, systems can include processes such as product development, distribution, promotion, and customer service. Each component interacts with others, and changes in one part often affect the entire system.

For example, a change in pricing strategy may influence demand, which in turn affects production schedules and distribution channels. Thinking of marketing as a system helps managers to see the bigger picture and avoid decisions that solve one problem but create another.

Fill in the blank: A system is a set of _____ components that work together to achieve a common goal.

1.2.2 System analysis for decision-making

System analysis is the process of studying how the parts of a system interact and contribute to overall performance. In marketing, system analysis involves examining flows of information, materials, and finances to identify bottlenecks or inefficiencies.

Managers use system analysis to evaluate the impact of decisions across the entire marketing system. For instance, introducing a new advertising campaign may increase demand, but system analysis helps determine whether production and distribution can handle the surge.

Fill in the blank: System analysis involves studying how the parts of a system _____ and contribute to overall performance.

1.2.3 Interrelationships between marketing subsystems

Marketing subsystems include areas such as product management, pricing, promotion, and distribution. These subsystems are interdependent, meaning that decisions in one area often influence others.

For example, a decision to lower prices may require adjustments in promotion strategies to communicate value, while distribution systems must adapt to increased demand. Recognising these interrelationships ensures that managers make decisions that are consistent and sustainable across the entire marketing system.

Fill in the blank: Marketing subsystems such as product, pricing, promotion, and distribution are _____, meaning decisions in one area influence others.

Pilot questions 1.2

1. What term refers to a set of interrelated components working together to achieve a goal?
2. What is the purpose of system analysis in marketing?
3. Which flows are typically examined during system analysis?
4. Give one example of how subsystems in marketing are interdependent.
5. Why is it important to recognise interrelationships among marketing subsystems?

1.3 Operational Research Foundations for Decision Analysis

1.3.1 Principles of operational research (OR)

Operational research (OR) is the application of scientific methods, mathematical models, and analytical techniques to decision-making problems. It provides managers with tools to evaluate alternatives systematically and to optimise outcomes. In marketing, OR helps in areas such as resource allocation, demand forecasting, and distribution planning.

The principles of OR emphasise objectivity, quantification, and optimisation. By relying on data and models rather than intuition alone, managers can make decisions that are more reliable and defensible.

Fill in the blank: Operational research applies scientific methods and _____ techniques to decision-making problems.

1.3.2 OR approaches to marketing decision problems

OR approaches in marketing include techniques such as linear programming, simulation, and statistical analysis. These methods allow managers to analyse complex problems involving multiple variables and constraints.

For example, linear programming can be used to determine the optimal mix of advertising channels within a budget, while simulation can test how different pricing strategies might affect demand. Each approach provides insights that support better decision-making.

Fill in the blank: Linear programming is often used to determine the optimal mix of _____ channels within a budget.

1.3.3 Case illustrations of OR in marketing

Case studies demonstrate how OR has been applied successfully in marketing contexts. For instance, a retail company may use OR models to optimise inventory levels, ensuring products are available without overstocking. Similarly, a logistics firm may apply OR to route planning, reducing delivery times and costs.

These illustrations highlight the practical value of OR in solving real-world marketing problems. They show that OR is not just theoretical, but a powerful tool for improving efficiency and competitiveness.

Fill in the blank: A logistics firm may apply OR to _____ planning, reducing delivery times and costs.

Pilot questions 1.3

1. What is operational research and how is it applied to decision-making?
2. Name two principles of operational research.
3. Which OR technique can be used to determine the optimal mix of advertising channels?
4. Give one example of how simulation can be applied in marketing.
5. Provide one case illustration of OR applied to marketing problems.

1.4 Introduction to Modelling and Simulation

1.4.1 Role of modelling in OR

Modelling is the process of creating simplified representations of real-world systems to study their behaviour and predict outcomes. In operational research, models help managers to analyse complex marketing problems by focusing on essential variables while ignoring unnecessary details.

For example, a pricing model may represent demand as a function of price, allowing managers to test different scenarios before making a decision. Models provide clarity and structure, enabling decision-makers to evaluate alternatives systematically.

Fill in the blank: Modelling involves creating simplified _____ of real-world systems to study their behaviour.

1.4.2 Simulation techniques for marketing decisions

Simulation refers to the use of models to imitate the operation of real-world processes over time. It allows managers to experiment with different strategies without the risks and costs of implementing them in reality.

In marketing, simulation can be used to test advertising campaigns, forecast demand, or evaluate distribution strategies. By running simulations, managers can observe how systems respond to changes and identify the most effective approaches.

Fill in the blank: Simulation allows managers to experiment with different strategies without the _____ of implementing them in reality.

1.4.3 Practical applications and limitations

Simulation and modelling are powerful tools, but they also have limitations. Applications include demand forecasting, resource allocation, and testing promotional strategies. However, limitations arise when models oversimplify reality or rely on inaccurate data.

Managers must balance the insights gained from models with practical judgement. A simulation may suggest an optimal advertising strategy, but external factors such as competitor actions or sudden market changes may alter the outcome.

Fill in the blank: One limitation of simulation is that models may _____ reality or rely on inaccurate data.

Pilot questions 1.4

1. What is modelling in operational research?
2. Give one example of how modelling can be applied in marketing.
3. What does simulation allow managers to do without incurring risks?
4. Name two applications of simulation in marketing.
5. Mention one limitation of simulation and modelling.

Series Summary

This Series has introduced you to the foundations of marketing decision analysis, highlighting its importance in guiding managers to make structured and rational choices in uncertain environments. The purpose was to equip you with the skills to define, analyse, and apply decision analysis techniques in marketing contexts, ensuring decisions are both systematic and effective.

We began by examining the elements of decision analysis, including types of decision situations and the use of decision trees. Then we explored systems and system analysis, focusing on how marketing subsystems interact and influence decision-making. Following that, we studied operational research foundations, emphasising principles, approaches, and case illustrations. Finally, we considered modelling and simulation, looking at their applications and limitations in marketing. By completing this Series, you should now be able to define the scope of decision analysis, explain decision situations, analyse systems, evaluate operational research approaches, and demonstrate modelling and simulation techniques, as outlined in the Series Learning Outcomes.

Glossary of Terms

- **Decision analysis**: A structured framework for making choices among alternatives when outcomes are uncertain.
- **Decision situation**: The context in which a choice must be made, classified as certainty, risk, or uncertainty.
- **Decision tree**: A graphical representation of decision problems showing alternatives, outcomes, and probabilities.

- **Modelling**: The creation of simplified representations of real-world systems to study their behaviour and predict outcomes.
- **Operational research (OR)**: The application of scientific methods, mathematical models, and analytical techniques to decision-making problems.
- **Simulation**: The use of models to imitate the operation of real-world processes over time, allowing experimentation with strategies.
- **System**: A set of interrelated components working together to achieve a common goal.
- **System analysis**: The study of how parts of a system interact and contribute to overall performance.

Concept Check Questions [Series 1]

Objective questions

1. Define decision analysis. (Linked to SLO 2.1)
2. Identify the three categories of decision situations. (Linked to SLO 2.2)
3. What graphical tool is used to represent decision problems with alternatives and outcomes? (Linked to SLO 2.2)
4. Which operational research technique can be used to determine the optimal mix of advertising channels? (Linked to SLO 2.4)
5. What term refers to a set of interrelated components working together to achieve a goal? (Linked to SLO 2.3)

Short-answer questions

6. Explain one way in which system analysis supports marketing decision-making. (Linked to SLO 2.3)
7. Give one example of how simulation can be applied in marketing. (Linked to SLO 2.5)
8. Describe one limitation of modelling and simulation in marketing. (Linked to SLO 2.5)

Long-answer questions

9. Analyse the differences between decision under certainty, risk, and uncertainty, providing marketing examples for each. (Linked to SLO 2.2)
10. Evaluate the role of operational research in marketing decision analysis, using case illustrations to support your answer. (Linked to SLO 2.4)

Answers to Concept Check Questions [Series 1]

Objective questions

1. Decision analysis is a structured framework for making choices among alternatives when outcomes are uncertain.
2. Certainty, risk, and uncertainty.

3. Decision tree.
4. Linear programming.
5. System.

Short-answer questions

6. System analysis helps managers evaluate how changes in one subsystem, such as pricing, affect others like distribution and promotion.

7. Simulation can be used to test advertising campaigns before implementation, predicting consumer responses.

8. One limitation is that models may oversimplify reality or rely on inaccurate data.

Long-answer questions

9. **Basic response**: Decision under certainty involves known outcomes, such as fixed supplier contracts. Decision under risk allows probabilities to be assigned, such as estimating demand for a new product. Decision under uncertainty involves unknown outcomes, such as entering a new market with unpredictable consumer behaviour. **Value-added response**: Beyond these distinctions, managers must recognise that real-world decisions often combine elements of risk and uncertainty. For example, launching a product in a familiar market may involve risk with known probabilities, while entering a new international market may involve uncertainty. Integrating probabilistic models with scenario planning can help bridge these contexts.

10. **Basic response**: Operational research provides tools such as linear programming, simulation, and statistical analysis to optimise marketing decisions. Case illustrations include inventory optimisation and advertising budget allocation. **Value-added response**: In addition to these applications, OR enhances strategic competitiveness by enabling firms to integrate data-driven insights into long-term planning. For example, logistics routing models not only reduce costs but also improve customer satisfaction, demonstrating OR's broader impact on marketing performance.

Answers to Pilot Questions [Series 1]

Part 1.1

1. Decision analysis
2. Certainty, risk, uncertainty
3. Risk
4. Decision tree
5. Product launch decisions

Part 1.2

1. System
2. To evaluate interactions and performance of subsystems

3. Information, materials, finances
4. Lowering prices affects promotion and distribution
5. To ensure consistency and sustainability across subsystems

Part 1.3

1. Operational research, applying scientific methods to decision-making
2. Objectivity and optimisation
3. Linear programming
4. Testing pricing strategies
5. Inventory optimisation, logistics routing

Part 1.4

1. Simplified representation of real-world systems
2. Pricing models in marketing
3. Risks and costs
4. Demand forecasting, promotional testing
5. Oversimplification or reliance on inaccurate data

Series 2: Operational Research Approaches in Marketing

Series outline

- **Part 2.1 Foundations of Operational Research in Marketing**
  - 2.1.1 Definition and scope of operational research
  - 2.1.2 Historical development and relevance to marketing
  - 2.1.3 Key principles guiding OR applications
- **Part 2.2 Systems Thinking and OR Applications**
  - 2.2.1 Concept of systems in operational research
  - 2.2.2 Systems approach to marketing decision problems
  - 2.2.3 Benefits and challenges of systems thinking
- **Part 2.3 Mathematical Programming Models in Marketing**
  - 2.3.1 Linear programming and resource allocation
  - 2.3.2 Transportation and assignment models
  - 2.3.3 Conflict analysis and game theory in marketing

- **Part 2.4 Case Applications of OR in Marketing**
  - 2.4.1 Inventory management and replacement models
  - 2.4.2 Line balancing, routing, and sequencing
  - 2.4.3 Project management applications in marketing

Introduction

In the last Series, we explored the foundations of marketing decision analysis, focusing on how managers can structure choices and apply tools such as decision trees, system analysis, and simulation. Building on that foundation, this Series shifts attention to operational research approaches, which provide more advanced techniques for solving marketing problems. Operational research is particularly relevant in today's competitive environment, where managers must optimise resources, balance conflicting objectives, and design strategies that are both efficient and effective.

The aim of this Series is to introduce you to the operational research approaches most applicable to marketing decisions and to equip you with the ability to apply these methods in practical contexts. By the end, you will be able to evaluate systems, apply mathematical programming models, and interpret case applications that demonstrate the value of operational research in marketing.

We shall commence this Series by examining the foundations of operational research in marketing, including its definition, scope, and guiding principles. Next, we will explore systems thinking and its applications to marketing decision problems. Following that, we will move on to mathematical programming models, such as linear programming, transportation, assignment, and game theory. Finally, we will wrap up by considering case applications of operational research in marketing, including inventory management, line balancing, routing, sequencing, and project management.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **2.1** define the scope and principles of operational research in marketing contexts,
- **2.2** explain how systems thinking can be applied to marketing decision problems,
- **2.3** apply mathematical programming models such as linear programming, transportation, and assignment to marketing scenarios,
- **2.4** analyse conflict situations using game theory in marketing decision-making, and
- **2.5** evaluate case applications of operational research in areas such as inventory management, routing, and project management.

2.1 Foundations of Operational Research in Marketing

2.1.1 Definition and scope of operational research

Operational research (OR) is the scientific application of mathematical models, analytical methods, and quantitative reasoning to decision-making problems. In marketing, OR provides

managers with systematic tools to optimise strategies such as pricing, distribution, and promotional planning.

The scope of OR in marketing extends to resource allocation, forecasting demand, evaluating alternatives, and improving efficiency across subsystems. By applying OR, managers can move beyond intuition and base decisions on structured analysis.

Fill in the blank: Operational research applies mathematical models and _____ reasoning to decision-making problems.

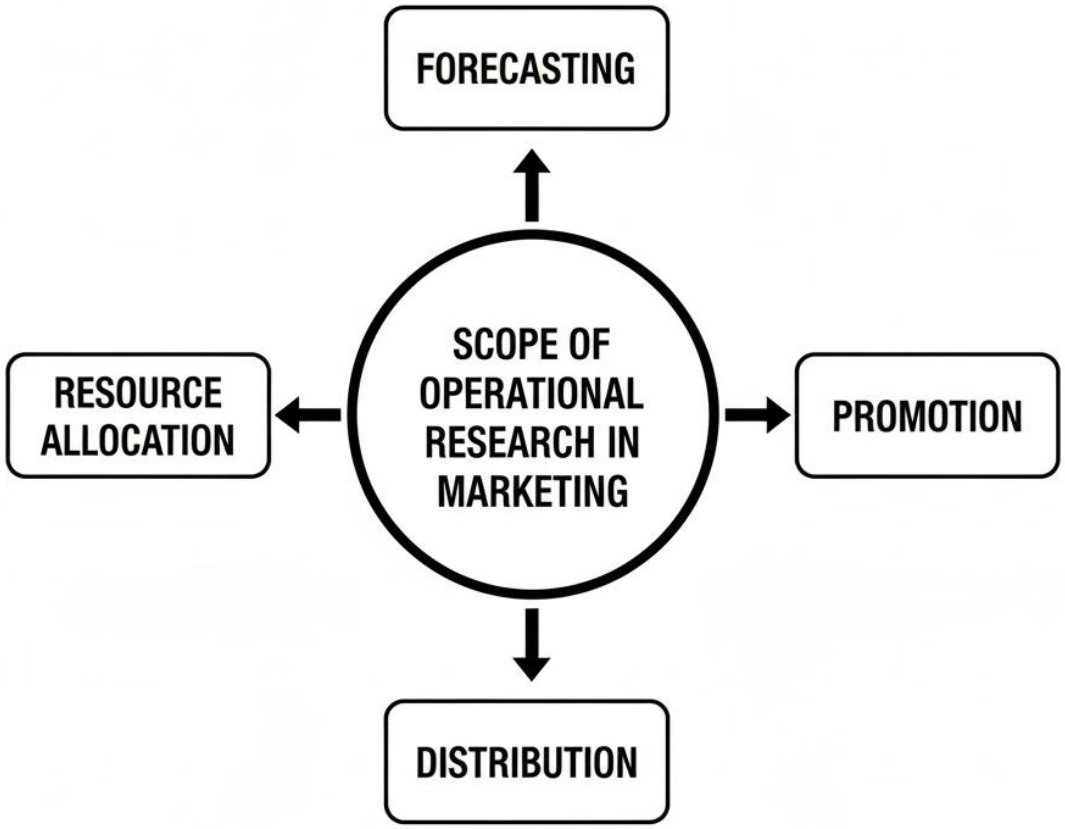


Figure 2.1 Scope of operational research in marketing

2.1.2 Historical development and relevance to marketing

Operational research originated during the Second World War, when scientists applied mathematical techniques to military logistics and resource planning. After the war, OR expanded

into business and industry, where its methods proved valuable for solving complex organisational problems.

In marketing, OR became relevant as markets grew more competitive and data-driven. Techniques such as linear programming and simulation allowed firms to optimise advertising budgets, manage inventories, and design distribution networks. Today, OR remains central to marketing decision analysis, helping managers balance costs, risks, and opportunities.

Fill in the blank: Operational research was first widely applied during the _____ World War to military logistics.

2.1.3 Key principles guiding OR applications

The principles of OR include **objectivity**, **quantification**, and **optimisation**.

- **Objectivity** means decisions are based on data and models rather than intuition.
- **Quantification** involves expressing problems in measurable terms, such as costs, probabilities, or demand levels.
- **Optimisation** refers to selecting the best possible solution among alternatives, often using mathematical programming.

In marketing, these principles ensure that strategies are not only creative but also efficient and evidence-based. For example, an advertising campaign can be evaluated quantitatively to determine which channels yield the highest return on investment.

Fill in the blank: The principle of _____ ensures that decisions are based on data and models rather than intuition.

Table 2.1 Principles of operational research and marketing applications

Principle of OR	Marketing Application
Objectivity	Data-driven decision making
Quantification	Market measurement, preditive analytics
Optimiation	Resource allocation, campaign scheduling

Pilot questions 2.1

1. What is operational research and how is it applied in marketing?
2. During which historical period was OR first widely applied?
3. Name the three guiding principles of operational research.
4. Which principle involves expressing problems in measurable terms?
5. Give one example of how OR can be applied to advertising decisions.

2.2 Systems Thinking and OR Applications

2.2.1 Concept of systems in operational research

A **system** is a collection of interrelated components working together towards a common objective. In operational research, systems are studied to understand how different parts interact and influence overall performance. In marketing, systems thinking helps managers recognise that decisions in one area, such as pricing, can affect other areas like distribution or promotion.

By viewing marketing as a system, managers can avoid isolated decisions and instead design strategies that consider the wider organisational impact.

Fill in the blank: A system is a collection of interrelated _____ working together towards a common objective.

Figure 2.2 Intercmcected substtyms in a marketing system

2.2.2 Systems approach to marketing decision problems

The **systems approach** involves analysing marketing problems by considering the entire system rather than focusing on isolated parts. It emphasises relationships, flows of information, and feedback loops.

For example, when planning a promotional campaign, managers must consider not only the advertising message but also how production, distribution, and customer service will respond to increased demand. The systems approach ensures that decisions are consistent and sustainable across the organisation.

Fill in the blank: The systems approach emphasises relationships, flows of information, and _____ loops.

Box 2.2 Steps in applying the systems approach

- Identify substiwns
- Map interactions
- Analyse flows
- Evaluate outcomes

Figure 2.2 Interconcected substytms in a marketing system

2.2.3 Benefits and challenges of systems thinking

Systems thinking offers several benefits, including improved coordination, better resource allocation, and enhanced decision quality. It helps managers anticipate unintended consequences and design strategies that align with organisational goals.

However, challenges include the complexity of modelling entire systems and the difficulty of obtaining accurate data. Managers must balance the insights gained from systems thinking with practical constraints.

Fill in the blank: One challenge of systems thinking is the difficulty of obtaining accurate _____.

Table 2.2 Benefits and challenges of systems thinking in marketing

Benefits	Chalenges
• Coordination • Resource allocation • Decision quality	• Complexity • Data accuracy

Pilot questions 2.2

1. What is a system in operational research?

2. What does the systems approach emphasise when analysing marketing problems?
3. Give one example of how the systems approach can be applied in marketing.
4. Name two benefits of systems thinking.
5. Mention one challenge of applying systems thinking in marketing.

2.3 Mathematical Programming Models in Marketing

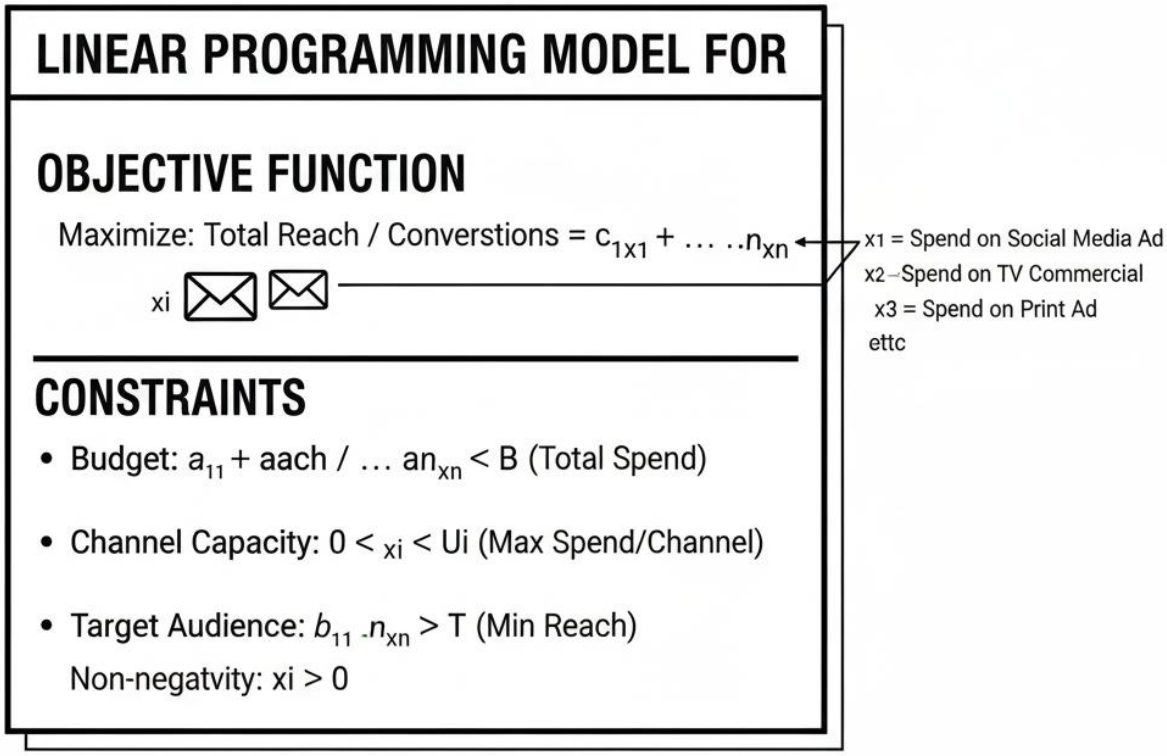
2.3.1 Linear programming and resource allocation

Linear programming (LP) is a mathematical technique used to determine the best allocation of limited resources among competing activities. In marketing, LP can be applied to optimise advertising budgets, distribution schedules, or product mixes.

For example, a company may want to maximise sales by allocating its advertising budget across television, radio, and online platforms. By formulating the problem as a linear programme, managers can identify the combination of channels that yields the highest return within budget constraints.

Fill in the blank: Linear programming is a mathematical technique used to determine the best _____ of limited resources.

Figure 2.3 Linear progamming model for advertising allocation



2.3.2 Transportation and assignment models

The **transportation model** is used to minimise the cost of distributing goods from multiple sources to multiple destinations. In marketing, it helps firms design efficient distribution networks.

The **assignment model** is used to allocate tasks or resources to specific agents in a way that minimises cost or maximises efficiency. For example, assigning sales representatives to territories based on potential revenue.

Fill in the blank: The transportation model is used to minimise the cost of distributing goods from multiple _____ to multiple destinations.

Table 2.3 Applications of transportation and assignment models in marketing

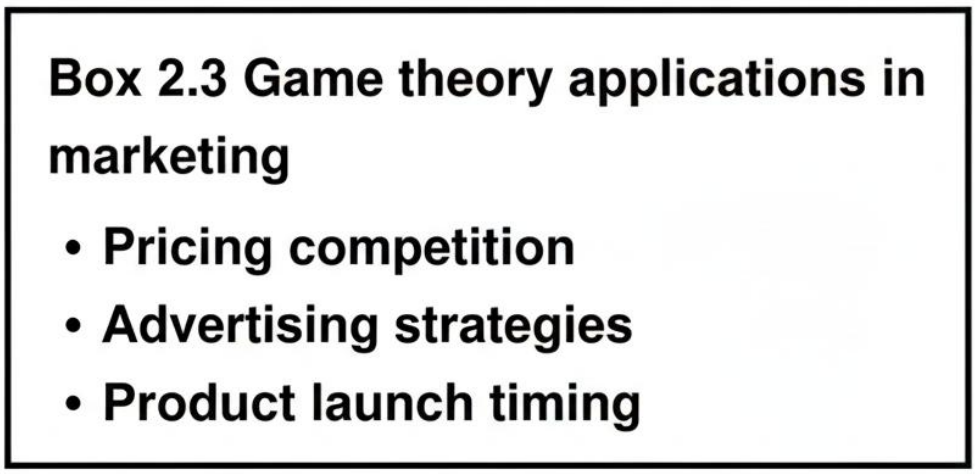
OR Model	Marketing Application
Transportation Model	Distribution cost minimization, supply chain optimization
Assignment Model	Sales territory allocation, advertising channel scheduling

2.3.3 Conflict analysis and game theory in marketing

Game theory is the study of strategic interactions where the outcome depends on the actions of multiple decision-makers. In marketing, game theory is used to analyse competitive situations such as pricing wars, product launches, or advertising strategies.

Conflict analysis involves examining situations where parties have opposing objectives. By applying game theory, managers can anticipate competitor behaviour and design strategies that maximise their own advantage.

Fill in the blank: Game theory is the study of strategic _____ where outcomes depend on multiple decision-makers.



Pilot questions 2.3

1. What is linear programming used for in marketing?
2. Which model helps minimise distribution costs across multiple sources and destinations?
3. What is the purpose of the assignment model?
4. Define game theory in the context of marketing.
5. Give one example of how conflict analysis can be applied in marketing.

2.4 Case Applications of OR in Marketing

2.4.1 Inventory management and replacement models

Inventory management refers to the process of ensuring that products are available to meet customer demand without incurring excessive storage costs. Operational research provides models that help managers determine optimal stock levels, reorder points, and safety margins.

Replacement models are used to decide when assets such as machinery or vehicles should be replaced to minimise costs and maintain efficiency. In marketing, these models ensure that distribution equipment or promotional tools remain effective and cost-efficient.

Fill in the blank: Inventory management ensures products are available to meet customer demand without incurring excessive _____ costs.

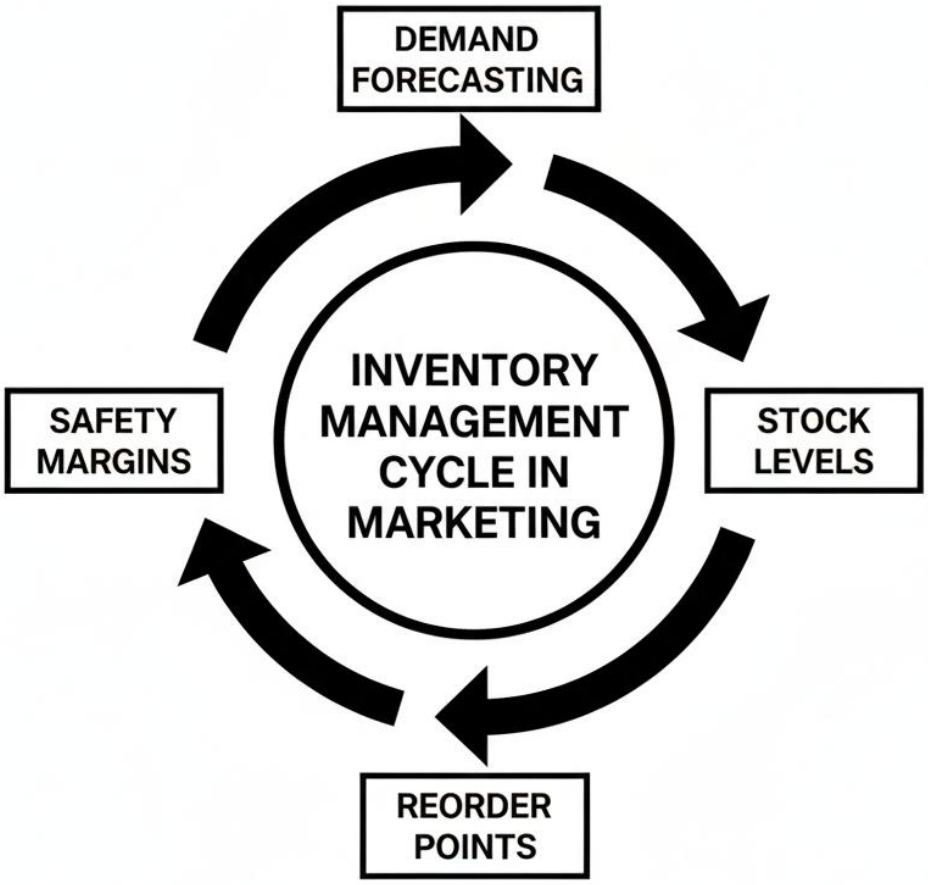


Figure 2.4 Inventory management cycle in marketing

2.4.2 Line balancing, routing, and sequencing

Line balancing involves arranging tasks in a production or service process so that workloads are evenly distributed. In marketing, this ensures that promotional activities or customer service operations run smoothly without bottlenecks.

Routing refers to determining the most efficient paths for distributing goods or services. For example, routing models can minimise delivery times and costs in logistics.

Sequencing is the process of determining the order in which tasks should be performed. In marketing, sequencing can be applied to scheduling promotional campaigns or product launches to maximise impact.

Fill in the blank: Routing refers to determining the most efficient _____ for distributing goods or services.

Table 2.4 Applications of line balancing, routing, and sequencing in marketing

OR Technique	Marketing Application
Line Balancing	Workload distribution for custom service / sales teams
Routing	Efficient delivery paths, sales force territory planning
Sequening	Task order optimization for campaign execution

2.4.3 Project management applications in marketing

Project management is the discipline of planning, organising, and controlling resources to achieve specific objectives within defined constraints. In marketing, project management is applied to campaigns, product launches, and market research projects.

Operational research contributes tools such as critical path analysis and PERT (Programme Evaluation and Review Technique), which help managers schedule tasks, allocate resources, and monitor progress. These tools ensure that marketing projects are completed on time and within budget.

Fill in the blank: Project management involves planning, organising, and controlling _____ to achieve specific objectives.

Box 2.4 OR tools for project management in marketing

- **Critical Path Analysis**
- **PERT (Program Evaluation and Review Technique)**

Figure 2.4 Inventory management cycle in marketing

Pilot questions 2.4

1. What is the purpose of inventory management in marketing?
2. What do replacement models help managers decide?
3. Define line balancing in the context of marketing operations.
4. Which OR technique is used to minimise delivery times and costs?
5. Name two tools used in project management applications of operational research.

Series Summary

This Series has focused on operational research approaches and their application to marketing decision problems. The purpose was to show how managers can move beyond intuition and apply structured, quantitative methods to optimise strategies and improve efficiency.

We began with the foundations of operational research, defining its scope and principles. Then we explored systems thinking, highlighting how subsystems interact and why a holistic approach is essential. Next, we examined mathematical programming models, including linear programming, transportation, assignment, and game theory. Finally, we considered case applications such as inventory management, routing, sequencing, and project management. By completing this Series, you should now be able to define OR principles, explain systems thinking, apply mathematical models, analyse competitive situations, and evaluate practical case applications, as outlined in the Series Learning Outcomes.

Glossary of Terms

- **Assignment model**: A mathematical model used to allocate tasks or resources to agents in a way that minimises cost or maximises efficiency.
- **Game theory**: The study of strategic interactions where outcomes depend on the actions of multiple decision-makers.
- **Inventory management**: The process of ensuring products are available to meet demand without incurring excessive storage costs.
- **Linear programming (LP)**: A mathematical technique used to determine the best allocation of limited resources among competing activities.
- **Project management**: The discipline of planning, organising, and controlling resources to achieve specific objectives within defined constraints.
- **Replacement models**: Models used to decide when assets should be replaced to minimise costs and maintain efficiency.
- **Routing**: Determining the most efficient paths for distributing goods or services.
- **Sequencing**: Determining the order in which tasks should be performed to maximise efficiency or impact.
- **System**: A collection of interrelated components working together towards a common objective.
- **Systems approach**: Analysing problems by considering the entire system, emphasising relationships, flows of information, and feedback loops.

Concept Check Questions [Series 2]

Objective questions

1. Define linear programming. (Linked to SLO 2.3)
2. Which model is used to minimise distribution costs across multiple sources and destinations? (Linked to SLO 2.3)
3. What is the purpose of the assignment model? (Linked to SLO 2.3)

4. During which historical period was operational research first widely applied? (Linked to SLO 2.1)

5. What does the systems approach emphasise when analysing marketing problems? (Linked to SLO 2.2)

Short-answer questions

6. Explain one benefit of systems thinking in marketing. (Linked to SLO 2.2)

7. Give one example of how game theory can be applied in marketing. (Linked to SLO 2.4)

8. Describe one application of project management tools in marketing. (Linked to SLO 2.5)

Long-answer questions

9. Analyse the principles of operational research and explain how they guide marketing decision-making. (Linked to SLO 2.1)

10. Evaluate the role of mathematical programming models in marketing, using examples such as linear programming and transportation models. (Linked to SLO 2.3)

Answers to Concept Check Questions [Series 2]

Objective questions

1. Linear programming is a mathematical technique used to determine the best allocation of limited resources.

2. The transportation model.

3. To allocate tasks or resources to agents efficiently.

4. The Second World War.

5. Relationships, flows of information, and feedback loops.

Short-answer questions

6. Systems thinking improves coordination and ensures decisions are consistent across subsystems.

7. Game theory can be applied to pricing competition, where firms anticipate competitor actions.

8. Project management tools such as PERT can be used to schedule tasks in a product launch.

Long-answer questions

9. **Basic response**: The principles of OR are objectivity, quantification, and optimisation. They guide marketing decisions by ensuring strategies are evidence-based, measurable, and efficient. **Value-added response**: Beyond these principles, OR integrates data-driven insights with strategic foresight. For example, quantification allows managers to measure advertising

effectiveness, while optimisation ensures resources are allocated to maximise returns. Together, these principles enhance competitiveness in dynamic markets.

10. **Basic response**: Mathematical programming models such as linear programming and transportation models help managers allocate resources and minimise distribution costs. **Value-added response**: In addition, these models provide flexibility in adapting to constraints and changing market conditions. For instance, linear programming can optimise advertising budgets, while transportation models improve logistics efficiency. Their combined use supports both tactical and strategic marketing decisions.

Answers to Pilot Questions [Series 2]

Part 2.1

1. Operational research is the scientific application of mathematical models and analytical methods to decision-making.
2. The Second World War.
3. Objectivity, quantification, optimisation.
4. Quantification.
5. Evaluating advertising channels for return on investment.

Part 2.2

1. A system is a collection of interrelated components working together towards a common objective.
2. Relationships, flows of information, and feedback loops.
3. Planning a promotional campaign while considering production and distribution.
4. Improved coordination, better resource allocation.
5. Difficulty of obtaining accurate data.

Part 2.3

1. To optimise resource allocation such as advertising budgets.
2. Transportation model.
3. To allocate tasks or resources efficiently.
4. Strategic interactions among decision-makers.
5. Pricing competition analysis.

Part 2.4

1. To ensure products are available to meet demand without excessive storage costs.
2. When assets should be replaced to minimise costs.
3. Arranging tasks so workloads are evenly distributed.

4. Routing models.
5. Critical path analysis and PERT.

Series 3: Modelling, Simulation, and Case Applications

Series Outline

- **Part 3.1 Introduction to Modelling in Marketing**
  - 3.1.1 Concept and purpose of modelling
  - 3.1.2 Types of models (deterministic, probabilistic, descriptive, prescriptive)
  - 3.1.3 Role of modelling in marketing decision analysis
- **Part 3.2 Simulation Techniques and Applications**
  - 3.2.1 Definition and scope of simulation
  - 3.2.2 Types of simulation (Monte Carlo, system dynamics, discrete event)
  - 3.2.3 Applications of simulation in marketing (demand forecasting, advertising response, distribution planning)
- **Part 3.3 Case Studies in Modelling and Simulation**
  - 3.3.1 Product launch simulation case
  - 3.3.2 Advertising budget allocation case
  - 3.3.3 Distribution and logistics optimisation case
- **Part 3.4 Limitations and Practical Considerations**
  - 3.4.1 Challenges of modelling and simulation (data accuracy, oversimplification, complexity)
  - 3.4.2 Balancing model insights with managerial judgement
  - 3.4.3 Ethical and practical issues in applying simulation to marketing

Introduction

In the previous Series, we examined operational research approaches in marketing, focusing on systems thinking, mathematical programming models, and practical case applications. Building on that foundation, this Series turns to modelling and simulation, which are powerful tools for representing complex marketing problems and experimenting with possible solutions. These approaches allow managers to test strategies in a safe environment before committing resources in reality.

The aim of this Series is to introduce you to modelling and simulation techniques and to demonstrate their application through case studies. By the end, you will be able to apply these tools to marketing decisions, evaluate their strengths and limitations, and appreciate their role in improving decision quality.

We shall commence this Series by exploring the concept of modelling in marketing, including its types and purpose. Next, we will examine simulation techniques and their applications to marketing problems such as demand forecasting and distribution planning. Following that, we will consider case studies that illustrate how modelling and simulation are applied in practice. Finally, we will conclude with a discussion of limitations and practical considerations, ensuring you understand both the potential and the boundaries of these methods.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **3.1** define the concept and types of modelling in marketing decision analysis,
- **3.2** explain the scope and techniques of simulation in marketing contexts,
- **3.3** apply simulation methods to marketing problems such as demand forecasting and advertising response,
- **3.4** analyse case studies that demonstrate modelling and simulation in marketing practice, and
- **3.5** evaluate the limitations and practical considerations of modelling and simulation in marketing decision-making.

3.1 Introduction to Modelling in Marketing

3.1.1 Concept and purpose of modelling

Modelling is the process of creating simplified representations of real-world systems to study their behaviour and predict outcomes. In marketing, models help managers to analyse complex problems by focusing on essential variables such as demand, costs, and consumer behaviour.

The purpose of modelling is to provide clarity, reduce complexity, and support decision-making. For example, a demand model may show how sales respond to changes in price, enabling managers to test scenarios before implementing strategies.

Fill in the blank: Modelling involves creating simplified _____ of real-world systems to study their behaviour.

Figure 3.1
Simplied marketing model

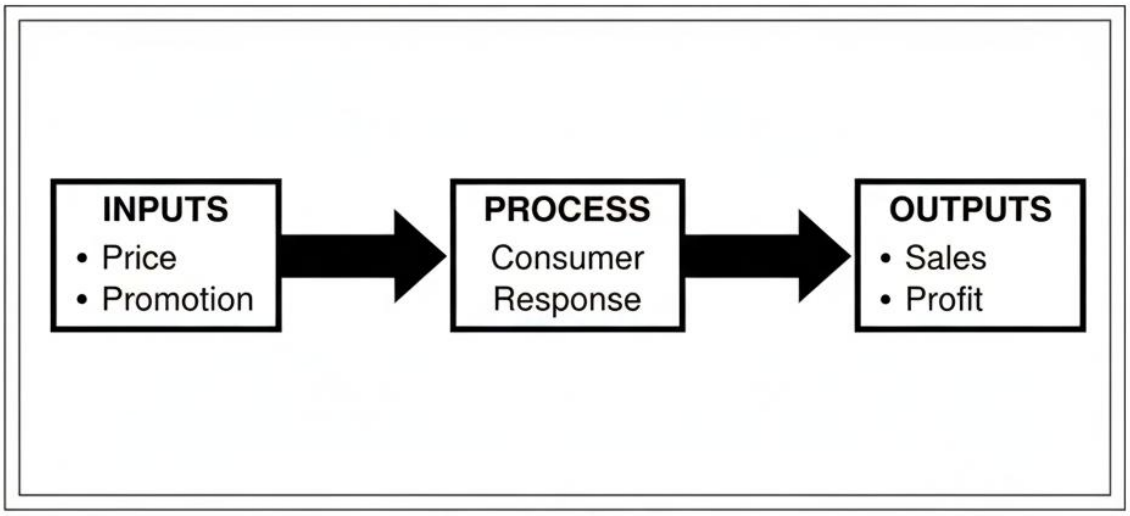


Figure 3.1 Simpllied marketing model

3.1.2 Types of models

Models can be classified into several types:

- **Deterministic models**: Assume outcomes are certain and predictable. For example, a fixed cost model.
- **Probabilistic models**: Incorporate uncertainty by assigning probabilities to outcomes, such as demand forecasts.
- **Descriptive models**: Represent systems without prescribing solutions, often used to understand consumer behaviour.
- **Prescriptive models**: Suggest optimal solutions, such as linear programming models for resource allocation.

Fill in the blank: Models that incorporate uncertainty by assigning probabilities to outcomes are called _____ models.

Table 3.1 Types of models in marketing decision analysis

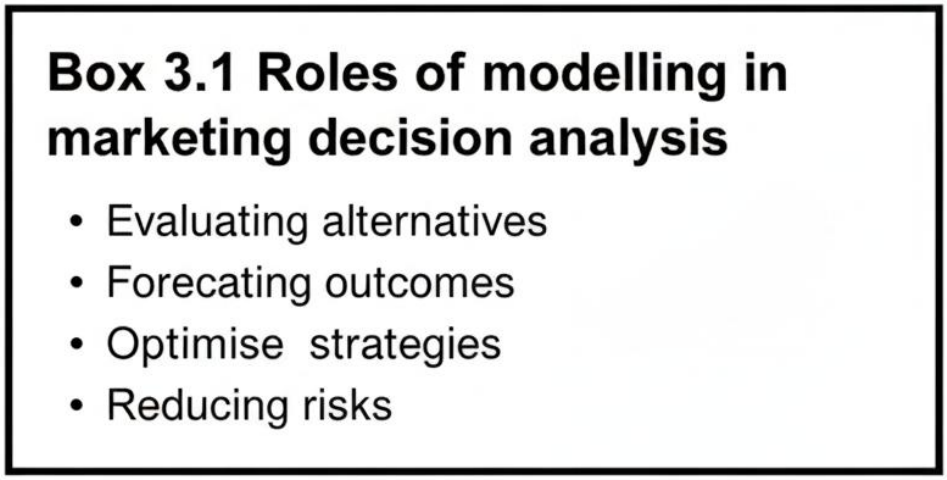
Model Type	Description	Marketing Example
Determistic	Predicts outcomes without randsmoss	Cost-volume-propit analysis
Probbisstic	Incorprates uncertinity and chance	Customer lifetime value (CLV) models
Prescritive	Explains past behavior or future	Marg[illegible]sts optimal actional actions fon algorithms

3.1.3 Role of modelling in marketing decision analysis

The role of modelling in marketing decision analysis is to provide managers with tools to evaluate alternatives, forecast outcomes, and optimise strategies. Models allow managers to experiment with different scenarios, such as pricing changes or promotional campaigns, without incurring real-world risks.

By using models, managers can identify the most effective strategies, anticipate competitor actions, and allocate resources more efficiently.

Fill in the blank: The role of modelling in marketing decision analysis is to provide managers with tools to _____ alternatives and forecast outcomes.



Pilot questions 3.1

1. What is modelling and why is it important in marketing?
2. Name the four types of models discussed in this Part.
3. Which type of model incorporates uncertainty by assigning probabilities to outcomes?
4. Give one example of how modelling can be applied to pricing decisions.
5. What is one role of modelling in marketing decision analysis?

3.2.1 Definition and scope of simulation

Simulation is the process of using models to imitate the operation of real-world systems over time. It allows managers to experiment with different strategies in a controlled environment without incurring the risks or costs of actual implementation.

In marketing, simulation is used to forecast demand, test advertising campaigns, and evaluate distribution strategies. By observing how systems respond to changes, managers can identify the most effective approaches before committing resources.

Fill in the blank: Simulation allows managers to experiment with strategies in a _____ environment without real-world risks.

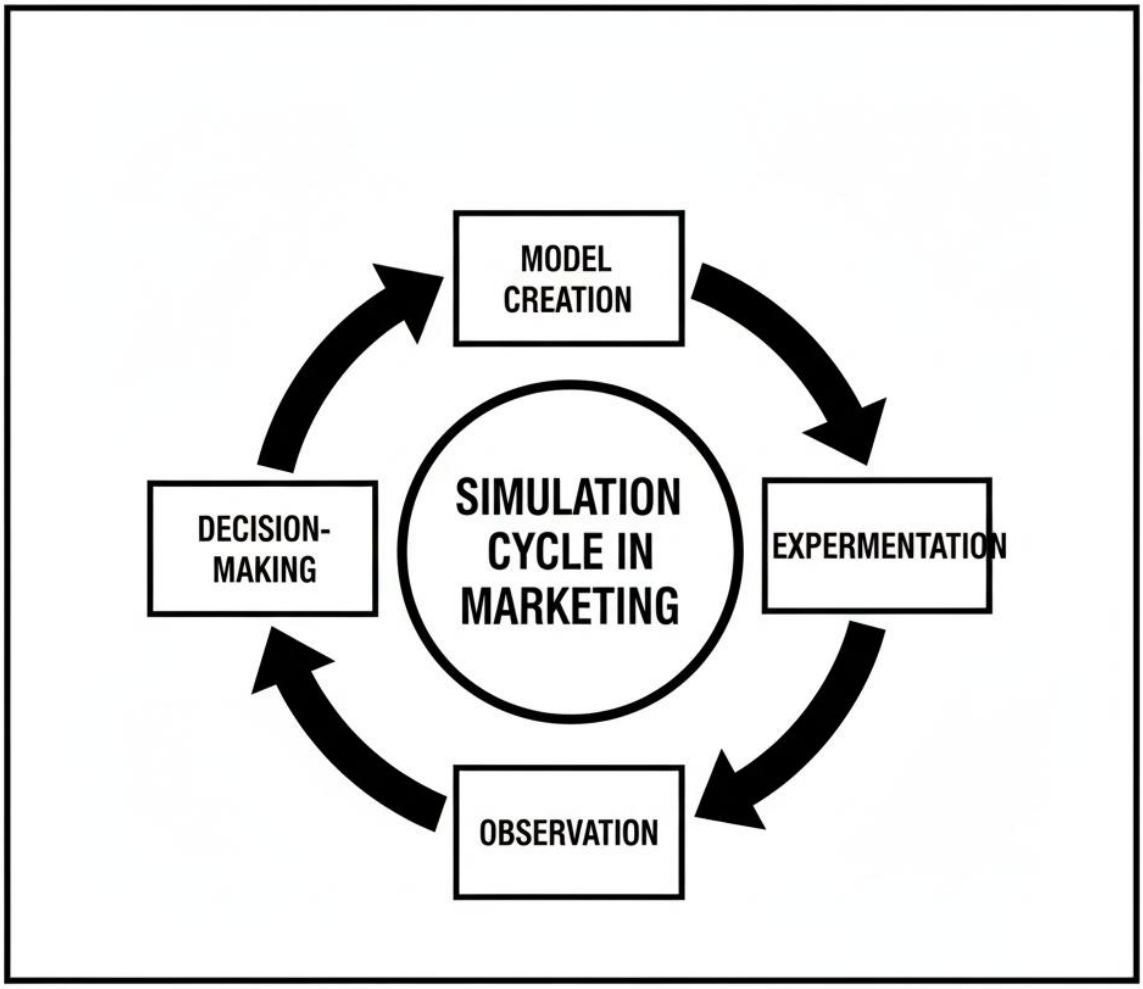


Figure 3.2 Simulation cycle in marketing

3.2.2 Types of simulation

There are several types of simulation commonly applied in marketing:

- **Monte Carlo simulation**: Uses random sampling to estimate probabilities and outcomes, often applied in risk analysis.
- **System dynamics simulation**: Focuses on feedback loops and time delays, useful for studying long-term marketing strategies.
- **Discrete event simulation**: Models systems as a sequence of events, often used in logistics and customer service operations.

Fill in the blank: Monte Carlo simulation uses random _____ to estimate probabilities and outcomes.

Table 3.2 Types of simulation and marketing applications	
Simulation Type	**Marketing Application**
Monte Carlo	Risk analysis, new product forecasting
System Dynamics	Long-term market share, competitive strategy
Discrete Event	Customer flow, call call center operations

3.2.3 Applications of simulation in marketing

Simulation has wide-ranging applications in marketing decision-making:

- **Demand forecasting**: Predicting future sales under different scenarios.
- **Advertising response analysis**: Testing how consumers might react to different advertising strategies.
- **Distribution planning**: Evaluating logistics networks to minimise costs and improve efficiency.

These applications help managers anticipate outcomes, allocate resources effectively, and design strategies that are resilient to uncertainty.

Fill in the blank: Simulation can be applied to advertising response analysis to test how _____ might react to campaigns.

Box 3.2 Applications of simulation in marketing

- Demand forecasting
- Advertising response analysis
- Distribution planning

Figure 3.2 Simulation cycle in marketing

Pilot questions 3.2

1. What is simulation and why is it important in marketing?
2. Name three types of simulation commonly applied in marketing.
3. Which type of simulation uses random sampling to estimate probabilities?
4. Give one example of how simulation can be applied to advertising decisions.
5. Mention one benefit of using simulation in distribution planning.

3.3.1 Product launch simulation case

Simulation can be applied to evaluate the potential success of a new product launch. By modelling consumer behaviour, market demand, and competitor responses, managers can test different launch strategies before committing resources.

For example, a company may simulate scenarios such as launching at different price points or targeting different customer segments. The results help managers identify the most promising strategy while reducing risk.

Fill in the blank: Simulation can be applied to evaluate the potential success of a new _____ launch.

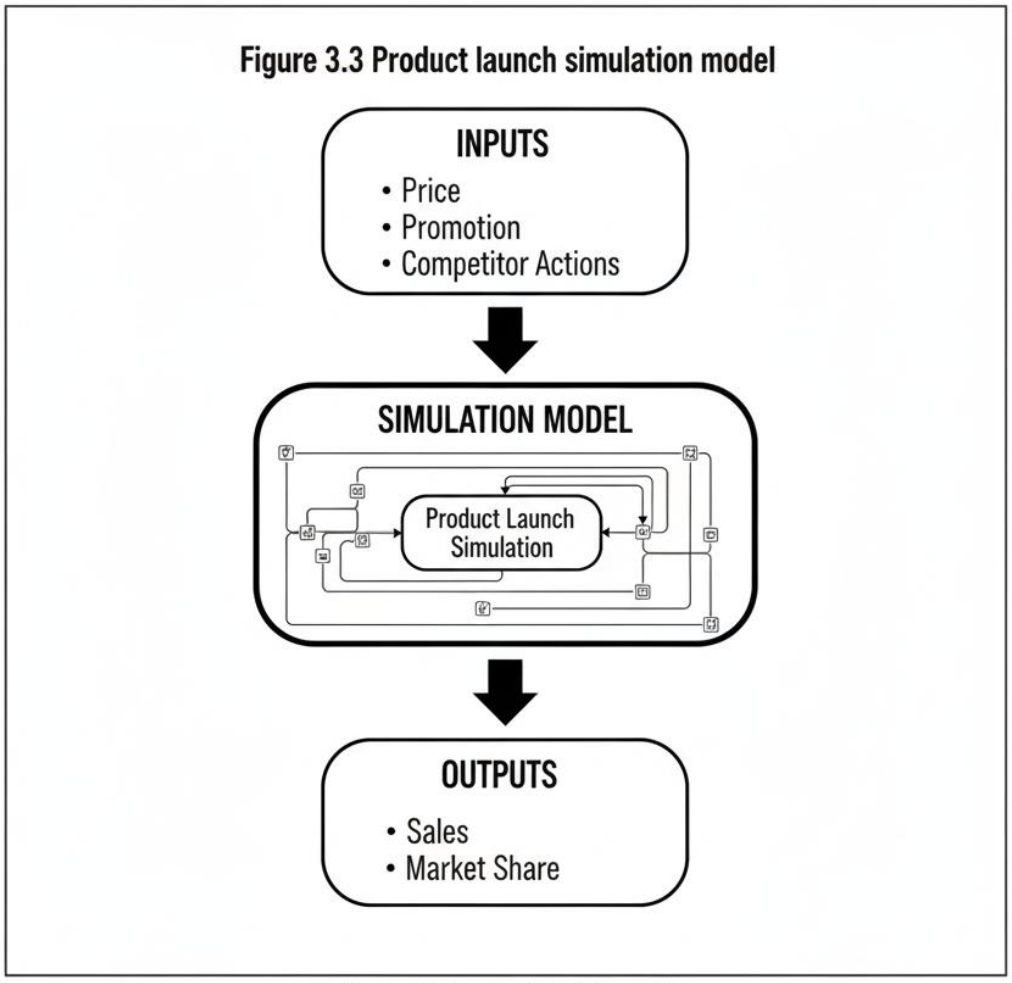


Figure 3.3 Product launch simulation model

3.3.2 Advertising budget allocation case

Modelling and simulation can also be used to optimise advertising budgets. By simulating consumer responses to different advertising channels, managers can determine the most effective allocation of funds.

For instance, a simulation may show that shifting budget from print media to digital platforms increases overall reach and engagement. This allows managers to make evidence-based decisions about advertising investments.

Fill in the blank: Simulation can help managers determine the most effective allocation of _____ in advertising.

Table 3.3 Advertising budget allocation simulation

Advertising Channel	Simulated Consumer Response	Simulated ROI (%)
TV	High reach, moderate engagement	8%
Radio	Moderate reach, low engagement	3%
Online	High reach, high engagement	15%
Print	Low reach, moderate engagement	6%

Figure 3.3 Product launch simulation model

3.3.3 Distribution and logistics optimisation case

Simulation is widely used in distribution and logistics to minimise costs and improve efficiency. By modelling delivery routes, warehouse operations, and customer demand, managers can identify bottlenecks and test alternative strategies.

For example, a logistics simulation may reveal that adjusting delivery schedules reduces costs while maintaining service quality. This supports better resource allocation and customer satisfaction.

Fill in the blank: Simulation is widely used in distribution and _____ to minimise costs and improve efficiency.

Box 3.3 Distribution and logistics optimization case

- **Delivery routing**
- **Warehouse operations**
- **Demand forceasting**

Figure 3.3 Product launch simulation model

Pilot questions 3.3

1. How can simulation be applied to a product launch?
2. What is the purpose of advertising budget allocation simulation?
3. Give one example of how simulation can improve distribution efficiency.
4. Which inputs might be included in a product launch simulation model?
5. Mention one benefit of using simulation in logistics planning.

3.4 Limitations and Practical Considerations

3.4.1 Challenges of modelling and simulation

While modelling and simulation provide powerful insights, they are not without challenges. One major issue is **data accuracy**: if the input data is flawed, the model's predictions will be unreliable. Another challenge is **oversimplification**, where models fail to capture the complexity of real-world marketing environments. Additionally, the **complexity of building and interpreting models** can make them difficult for managers without technical expertise.

Fill in the blank: One major challenge of modelling and simulation is ensuring the accuracy of _____ data.

Figure 3.4 Challenges of modelling and simulation in marketing

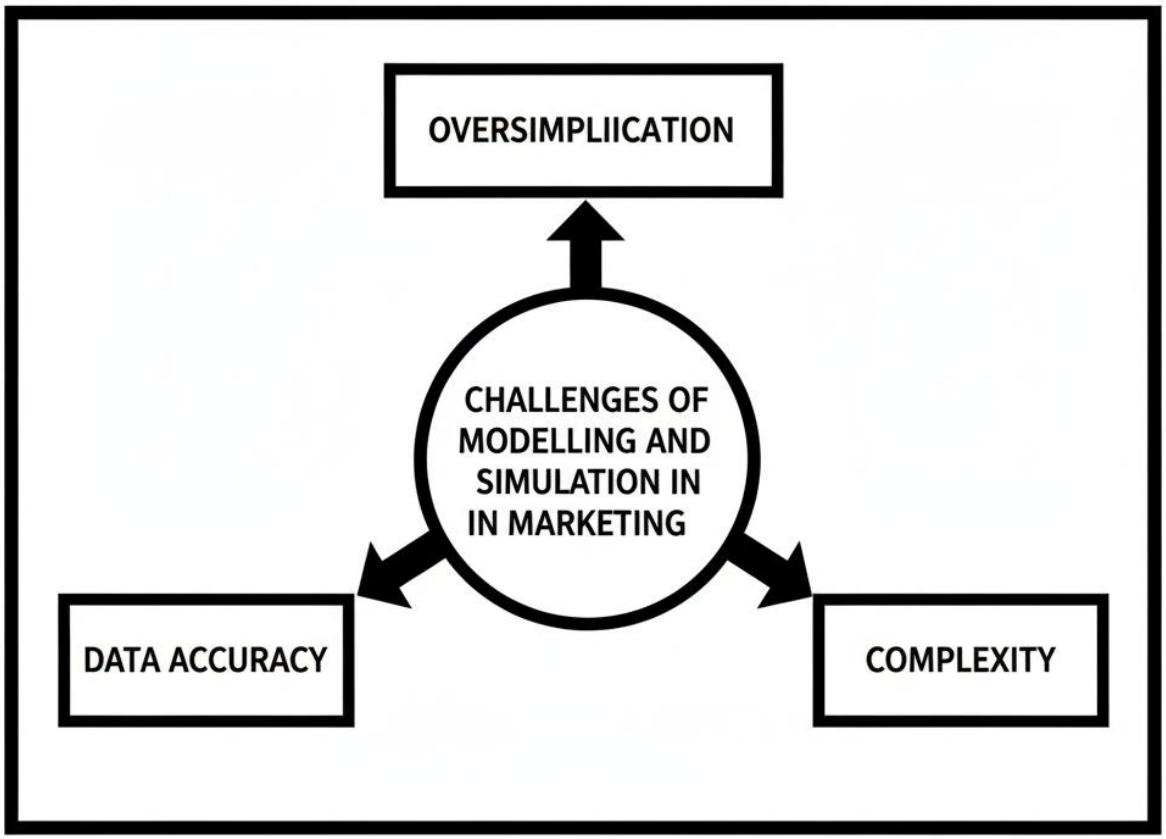


Figure 3.4 Challenges of modelling and simulation in marketing

3.4.2 Balancing model insights with managerial judgement

Models and simulations are valuable tools, but they should not replace managerial judgement. Managers must balance quantitative insights with qualitative factors such as consumer psychology, brand reputation, and market trends.

For example, a simulation may suggest cutting advertising spend to reduce costs, but managerial judgement may recognise the long-term importance of maintaining brand visibility.

Fill in the blank: Managers must balance quantitative insights with qualitative factors such as consumer _____ and brand reputation.

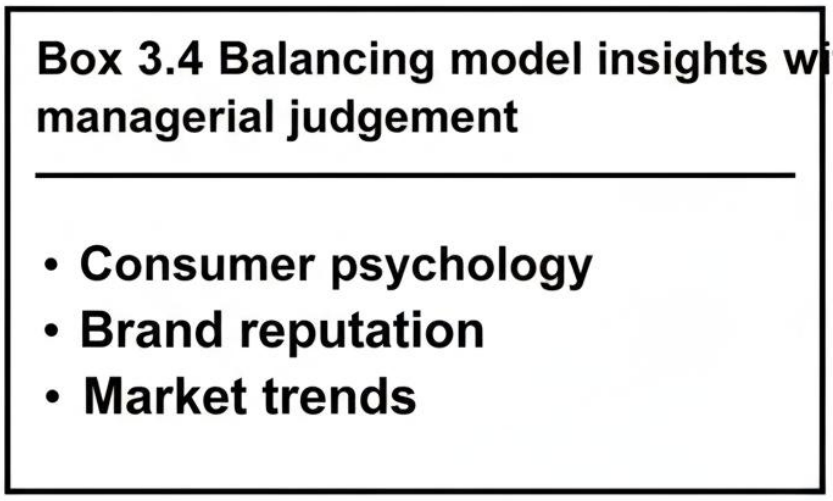


Figure 3.4 Challenges of modelling and simulation in marketing

3.4.3 Ethical and practical issues in applying simulation to marketing

Ethical and practical issues also arise when applying simulation in marketing. For instance, using consumer data in simulations must respect privacy and data protection laws. There is also the risk of bias in models, which can lead to unfair or misleading outcomes.

Practically, simulations require resources such as time, expertise, and computing power, which may not always be available. Managers must weigh these considerations before relying heavily on simulation results.

Fill in the blank: Using consumer data in simulations must respect privacy and _____ protection laws.

Table 3.4 Ethical and practical issues in simulation

Issue Type	Details
Ethical Issues	• Privacy concerns, data security • Algorithhic bias, fairness
Practical Issues	• Computational resources • Required expertise • Data availablity/quality

Figure 3.4 Challenges of modeling and simulation in marketing

Pilot questions 3.4

1. What is one major challenge of modelling and simulation?

2. Why should managerial judgement complement model insights?
3. Mention one qualitative factor that managers must consider in marketing decisions.
4. What ethical issue must be respected when using consumer data in simulations?
5. Name one practical limitation of applying simulation in marketing.

Series Summary

This Series has introduced you to modelling and simulation as essential tools for marketing decision analysis. The purpose was to show how managers can represent complex problems in simplified forms, experiment with strategies, and anticipate outcomes before committing resources.

We began by defining modelling and its types, then moved on to simulation techniques such as Monte Carlo, system dynamics, and discrete event approaches. Following that, we explored case studies including product launch simulations, advertising budget allocation, and logistics optimisation. Finally, we considered limitations and practical issues, emphasising the need to balance model insights with managerial judgement and ethical considerations. By completing this Series, you should now be able to define modelling, explain simulation techniques, apply them to marketing problems, analyse case studies, and evaluate their limitations, as outlined in the Series Learning Outcomes.

Glossary of Terms

- **Advertising budget allocation simulation**: A model used to test and optimise how funds are distributed across advertising channels.
- **Deterministic model**: A type of model that assumes outcomes are certain and predictable.
- **Discrete event simulation**: A simulation method that models systems as a sequence of events, often used in logistics.
- **Monte Carlo simulation**: A technique that uses random sampling to estimate probabilities and outcomes.
- **Modelling**: The creation of simplified representations of real-world systems to study behaviour and predict outcomes.
- **Prescriptive model**: A model that suggests optimal solutions to decision problems.
- **Probabilistic model**: A model that incorporates uncertainty by assigning probabilities to outcomes.
- **Simulation**: The use of models to imitate the operation of real-world processes over time.
- **System dynamics simulation**: A simulation method focusing on feedback loops and time delays in systems.
- **Systems approach**: Analysing problems by considering the entire system and its interactions.

Concept Check Questions [Series 3]

Objective questions

1. Define modelling in marketing decision analysis. (Linked to SLO 3.1)
2. Name the four types of models discussed in this Series. (Linked to SLO 3.1)
3. Which type of simulation uses random sampling to estimate probabilities? (Linked to SLO 3.2)
4. What is the purpose of advertising budget allocation simulation? (Linked to SLO 3.3)
5. Mention one challenge of modelling and simulation. (Linked to SLO 3.5)

Short-answer questions

6. Explain one application of simulation in demand forecasting. (Linked to SLO 3.3)
7. Give one example of how simulation can be applied to logistics. (Linked to SLO 3.3)
8. Describe one ethical issue in applying simulation to marketing. (Linked to SLO 3.5)

Long-answer questions

9. Analyse the types of models used in marketing decision analysis, providing examples for each. (Linked to SLO 3.1)
10. Evaluate the role of simulation in marketing, using case studies such as product launch and distribution planning. (Linked to SLO 3.3, SLO 3.4)

Answers to Concept Check Questions [Series 3]

Objective questions

1. Modelling is the creation of simplified representations of real-world systems to study behaviour and predict outcomes.
2. Deterministic, probabilistic, descriptive, prescriptive.
3. Monte Carlo simulation.
4. To test and optimise how funds are distributed across advertising channels.
5. Data accuracy.

Short-answer questions

6. Simulation can be used to forecast demand under different scenarios, helping managers anticipate sales levels.
7. Logistics simulation can optimise delivery routes to reduce costs and improve efficiency.
8. Using consumer data in simulations must respect privacy and data protection laws.

Long-answer questions

9. **Basic response**: Deterministic models assume certainty, probabilistic models incorporate uncertainty, descriptive models explain systems, and prescriptive models suggest optimal solutions. Examples include fixed cost models, demand forecasts, consumer behaviour studies, and linear programming. **Value-added response**: Beyond these categories, models can be integrated to provide richer insights. For instance, probabilistic demand forecasts can feed into prescriptive optimisation models, allowing managers to balance risk and efficiency. This integration enhances decision quality in dynamic markets.

10. **Basic response**: Simulation helps managers test strategies such as product launches, advertising budgets, and distribution planning before implementation. **Value-added response**: Case studies show that simulation not only reduces risk but also improves strategic foresight. For example, product launch simulations anticipate competitor responses, while logistics simulations optimise delivery networks. Together, these applications demonstrate simulation's role in enhancing both tactical and strategic marketing decisions.

Answers to Pilot Questions [Series 3]

Part 3.1

1. Modelling is the process of creating simplified representations of real-world systems to study behaviour.
2. Deterministic, probabilistic, descriptive, prescriptive.
3. Probabilistic models.
4. Testing how sales respond to price changes.
5. To evaluate alternatives and forecast outcomes.

Part 3.2

1. Simulation imitates real-world systems to test strategies safely.
2. Monte Carlo, system dynamics, discrete event.
3. Monte Carlo simulation.
4. Testing consumer reactions to advertising campaigns.
5. Minimising costs and improving efficiency.

Part 3.3

1. By modelling consumer behaviour, demand, and competitor responses.
2. To optimise how funds are distributed across advertising channels.
3. Adjusting delivery schedules to reduce costs.
4. Inputs such as price, promotion, competitor actions.
5. Improved resource allocation and customer satisfaction.

Part 3.4

1. Data accuracy.
2. Because qualitative factors like brand reputation must be considered.
3. Consumer psychology.
4. Privacy protection.
5. Requirement for computing resources and expertise.

Series 4: Mathematical Programming and Strategic Models

Series Outline

- **Part 4.1 Introduction to Mathematical Programming in Marketing**
  - 4.1.1 Concept and importance of mathematical programming
  - 4.1.2 Types of mathematical programming models (linear, integer, nonlinear)
  - 4.1.3 Applications in marketing decision-making
- **Part 4.2 Linear and Integer Programming Applications**
  - 4.2.1 Linear programming for resource allocation and product mix
  - 4.2.2 Integer programming for discrete marketing decisions (e.g., media selection, facility location)
  - 4.2.3 Case examples in marketing optimisation
- **Part 4.3 Nonlinear Programming and Strategic Models**
  - 4.3.1 Nonlinear programming in pricing and demand analysis
  - 4.3.2 Strategic models for competitive behaviour (game theory revisited, Nash equilibrium)
  - 4.3.3 Strategic planning applications in marketing
- **Part 4.4 Advanced Case Applications and Limitations**
  - 4.4.1 Case study: advertising strategy optimisation
  - 4.4.2 Case study: distribution and logistics planning
  - 4.4.3 Limitations and practical considerations of mathematical programming in marketing

Introduction

In the last Series, we explored modelling and simulation, focusing on how managers can represent complex marketing problems and test strategies in a safe environment. Building on that foundation, this Series turns to **mathematical programming and strategic models**, which provide more advanced tools for optimising marketing decisions and analysing competitive

behaviour. These approaches are particularly valuable in situations where resources are limited, decisions are discrete, or market dynamics are complex.

The aim of this Series is to introduce you to mathematical programming techniques and strategic models, and to demonstrate how they can be applied to marketing problems such as resource allocation, pricing, and competitive strategy. By the end, you will be able to apply linear, integer, and nonlinear programming methods, interpret strategic models, and evaluate their practical applications in marketing contexts.

We shall commence this Series by examining the concept and importance of mathematical programming in marketing. Next, we will explore linear and integer programming applications, including resource allocation and media selection. Following that, we will move on to nonlinear programming and strategic models, with a focus on pricing and competitive behaviour. Finally, we will conclude with advanced case applications and limitations, ensuring you understand both the potential and boundaries of these methods.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **4.1** define the concept and types of mathematical programming models in marketing decision analysis,
- **4.2** apply linear programming techniques to resource allocation and product mix problems,
- **4.3** demonstrate the use of integer programming in discrete marketing decisions such as media selection,
- **4.4** analyse nonlinear programming applications in pricing and demand analysis,
- **4.5** evaluate strategic models for competitive behaviour, including game theory and Nash equilibrium, and
- **4.6** assess case applications and limitations of mathematical programming in marketing practice.

4.1 Introduction to Mathematical Programming in Marketing

4.1.1 Concept and importance of mathematical programming

Mathematical programming refers to the use of mathematical models and optimisation techniques to solve decision problems involving constraints and objectives. In marketing, it helps managers allocate scarce resources, design efficient strategies, and maximise outcomes such as profit, market share, or customer satisfaction.

Its importance lies in providing structured, evidence-based solutions to complex problems. For example, a company may use mathematical programming to determine the optimal mix of products to produce within budget and capacity limits.

Fill in the blank: Mathematical programming uses mathematical models and _____ techniques to solve decision problems.

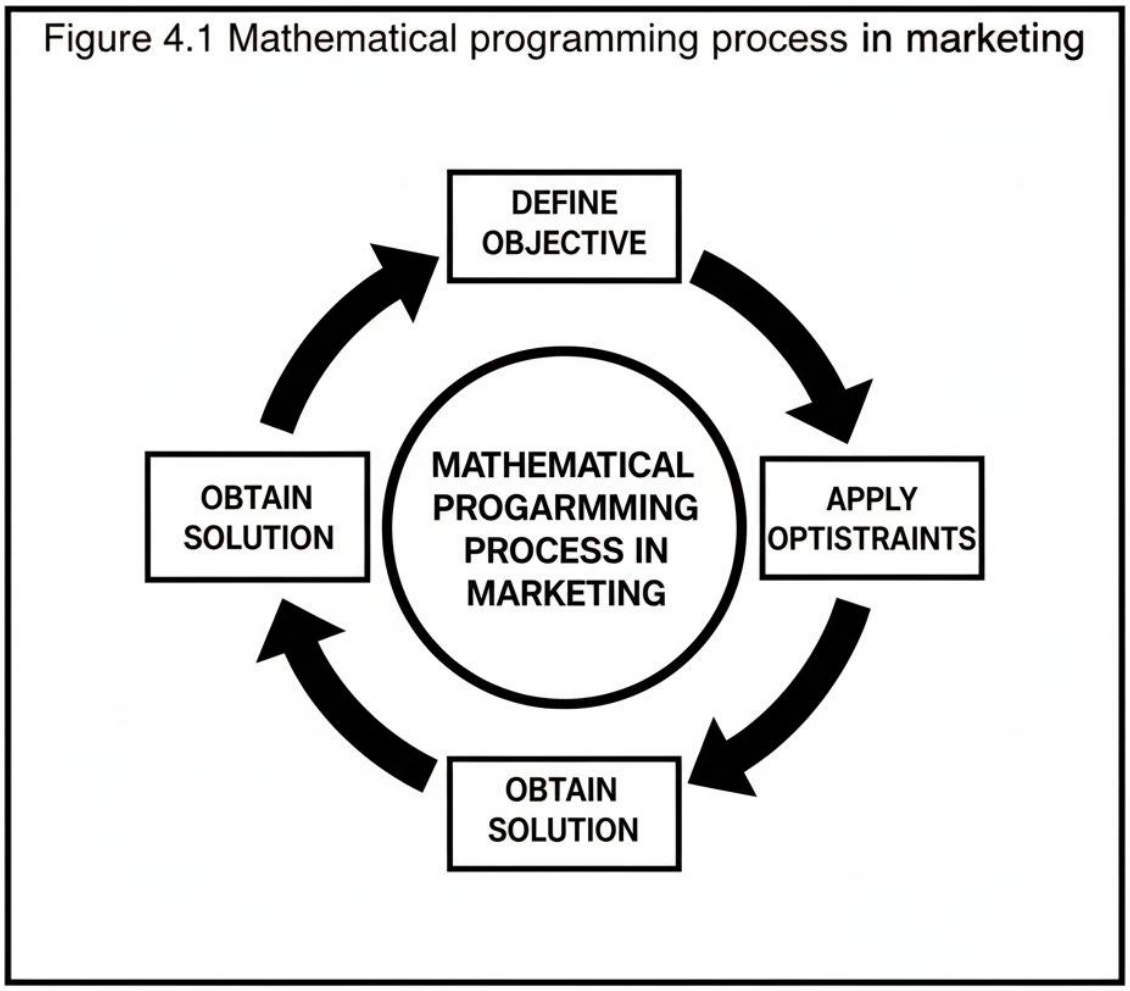


Figure 3.1 Simulation cycle in marketing

4.1.2 Types of mathematical programming models

There are several types of mathematical programming models relevant to marketing:

- **Linear programming (LP)**: Models with linear objectives and constraints, used for resource allocation and product mix.
- **Integer programming (IP)**: Models where decision variables must take whole numbers, useful for discrete decisions such as facility location or media selection.

- **Nonlinear programming (NLP)**: Models with nonlinear objectives or constraints, often applied to pricing and demand analysis.

Fill in the blank: Models where decision variables must take whole numbers are called _____ programming models.

Table 4.1 Types of mathematical programming models and marketing applications

Model Type	Marketing Application
Linear Programming (LP)	Media mix optimization, resource allocation
Integer Programming (IP)	Facility location, sales force territory design
Nonlollar Programming (NLP)	Pricing strategies, demand curve estimation

Figure 4.1 Mathematical programming process in marketing

4.1.3 Applications in marketing decision-making

Mathematical programming is widely applied in marketing decision-making:

- **Resource allocation**: Optimising advertising budgets across channels.
- **Product mix decisions**: Determining which products to produce given capacity and demand.

- **Pricing strategies**: Using nonlinear models to set prices that maximise profit.
- **Distribution planning**: Applying integer programming to select warehouse locations.

These applications demonstrate how mathematical programming supports both tactical and strategic marketing decisions.

Fill in the blank: Mathematical programming can be applied to optimise _____ budgets across advertising channels.

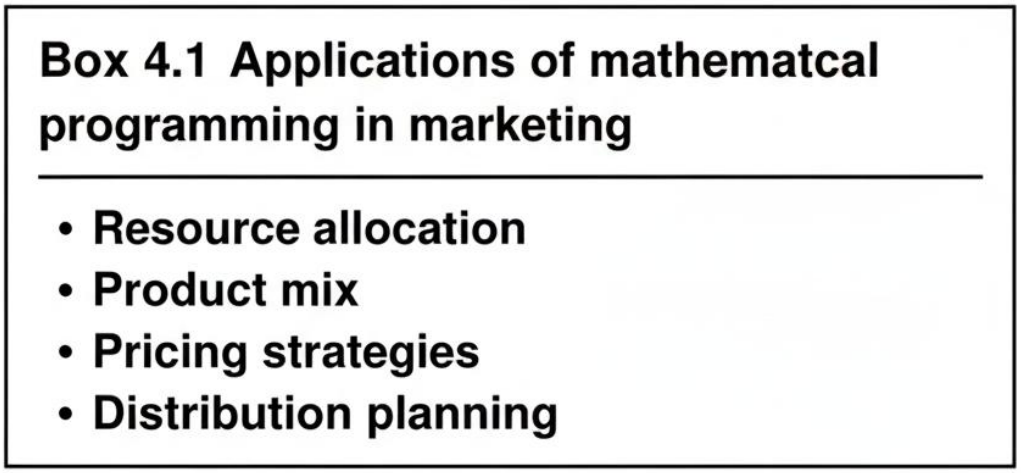


Figure 4.1 Mathematical programming process in marketing

Pilot questions 4.1

1. What is mathematical programming and why is it important in marketing?
2. Name the three types of mathematical programming models discussed in this Part.

3. Which type of model requires decision variables to be whole numbers?
4. Give one example of how mathematical programming can be applied to advertising decisions.
5. Mention one application of nonlinear programming in marketing.

4.2 Linear and Integer Programming Applications

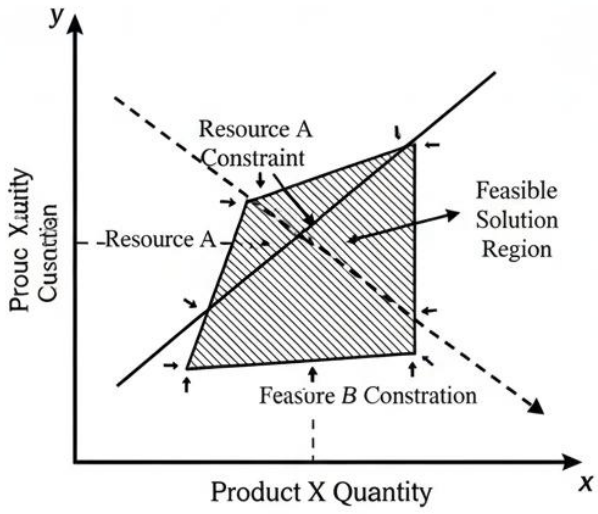
4.2.1 Linear programming for resource allocation and product mix

Linear programming (LP) is widely used in marketing to optimise resource allocation and product mix decisions. It involves formulating an objective function (such as maximising profit or minimising cost) subject to linear constraints (such as budget limits or production capacity).

For example, a firm may use LP to determine the optimal combination of products to produce, given limited raw materials and demand forecasts. Similarly, LP can be applied to allocate advertising budgets across channels to maximise reach.

Fill in the blank: Linear programming involves formulating an objective function subject to _____ constraints.

Figure 4.2 Linear programming model for product mix



Objective Function:

Maximize $Z = c_1X + c_2Y$ Objective Function: Maximize Profit

Constraints:

$a_1X + b\,bY \leq R_2$

$X, Y = 0$

Figure 4.2 Linear programming model for process in markct mix

4.2.2 Integer programming for discrete marketing decisions

Integer programming (IP) is used when decision variables must take whole numbers. This is particularly relevant in marketing for discrete decisions such as media selection, facility location, or assigning sales representatives to territories.

For instance, a company may use IP to decide how many advertisements to place in each media outlet, ensuring that the number of ads is a whole number and within budget.

Fill in the blank: Integer programming is used when decision variables must take _____ numbers.

Table 4.2 Applications of integer programming in marketing

Application	Description
Media Selection	Optimizing the choice of advertising channels (TV, radio, online, print) to maximize reach or impressions within a budget, where channel allocation must be whole units.
Facility Location	Determing the optimal locations for new warehouses or retail stores to serve customer demand, with each facility being a distinct, indvisible unit.
Sales Territory Assignment	Assigning sales represetatives to geogaphic territories to balance a balance waximize maximize sales potential, where where each territory a asigned a single rep.

Figure 4.2 Linear programming model for product mix

4.2.3 Case examples in marketing optimisation

Case applications of LP and IP demonstrate their practical value:

- **Advertising allocation**: LP used to distribute budgets across channels for maximum impact.
- **Facility location**: IP applied to select optimal warehouse sites to minimise distribution costs.
- **Sales territory assignment**: IP used to allocate representatives to regions based on potential revenue.

These cases highlight how mathematical programming supports efficient and evidence-based marketing decisions.

Fill in the blank: Integer programming can be applied to facility _____ decisions to minimise distribution costs.

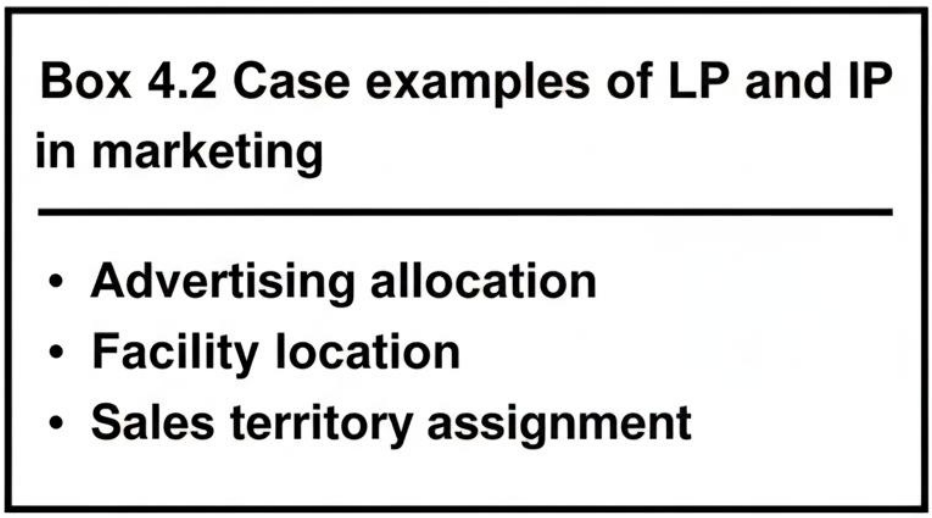


Figure 4.2 Linear progamming model for product mix

Pilot questions 4.2

1. What is the purpose of linear programming in marketing?
2. Which type of programming is used for discrete decisions?
3. Give one example of how LP can be applied to advertising.
4. Mention one application of integer programming in marketing.
5. What is the role of case applications in demonstrating LP and IP?

4.3.1 Nonlinear programming in pricing and demand analysis

Nonlinear programming (NLP) is used when either the objective function or constraints are nonlinear. In marketing, this is particularly relevant for pricing and demand analysis, where relationships between price and demand are rarely linear.

For example, demand often decreases at a diminishing rate as price increases, requiring nonlinear models to capture the true behaviour. NLP helps managers set prices that maximise profit while considering complex demand patterns.

Fill in the blank: Nonlinear programming is used when the objective function or _____ are nonlinear.

Figure 4.3 Nolnoelar programming in pricing and demand analysis

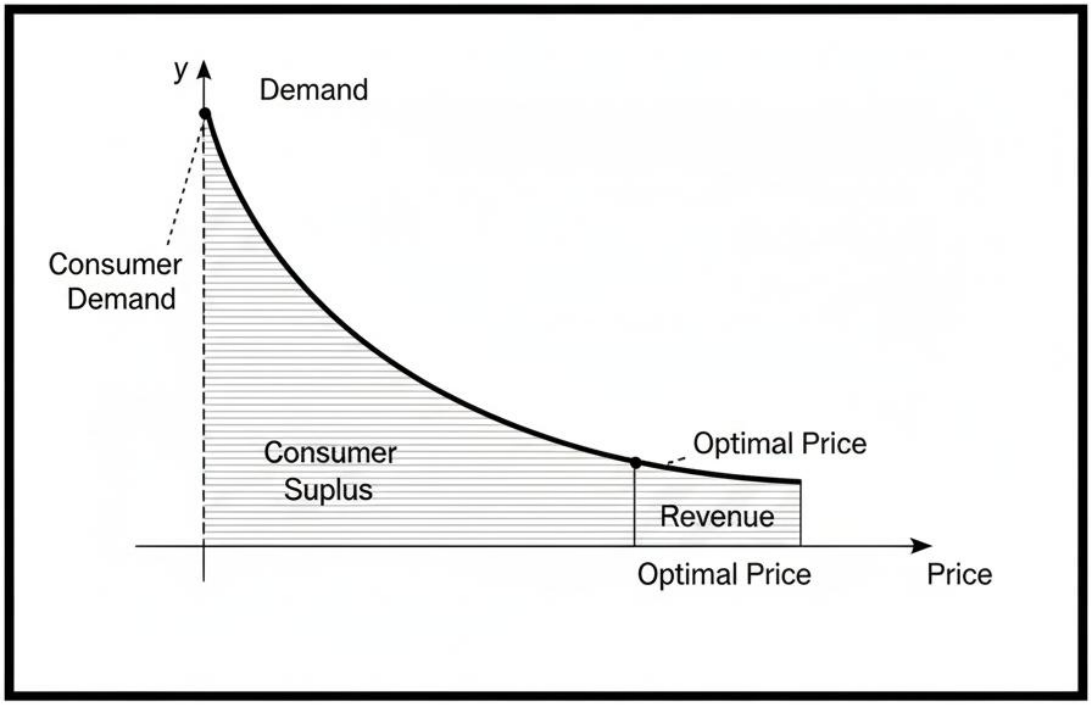


Figure 4.3 Nolnoelar programming in pricing and demand analysis

4.3.2 Strategic models for competitive behaviour

Strategic models help managers analyse competitive behaviour in markets. **Game theory** is a key tool, focusing on interactions where outcomes depend on the actions of multiple firms. Concepts such as **Nash equilibrium** show how competitors may settle into stable strategies where no one benefits from changing unilaterally.

In marketing, strategic models are applied to pricing wars, advertising competition, and product launch timing. They allow managers to anticipate competitor actions and design strategies that maximise advantage.

Fill in the blank: A Nash equilibrium occurs when no competitor benefits from changing strategy _____.

Table 4.3 Strategic models and marketing applications

Strategic Model	Marketing Application
Game Theory	Competitive pricing strategies, advertising campaign planning, new product launch timing, market entry/exit decisions
Nash Equilbrlum	Predicting stable outcomes in compettive, determining optimal strategies in pricing wars, understanding competitive adwertising spend spend levels

Figure 4.3 Nionnelar programming in pricing and demand analysis

4.3.3 Strategic planning applications in marketing

Strategic models are also used in long-term planning. By combining mathematical programming with strategic analysis, managers can design robust marketing strategies that balance short-term gains with long-term sustainability.

Applications include planning multi-year advertising campaigns, designing competitive pricing strategies, and coordinating product launches across markets. These models ensure that marketing decisions are not only optimal but also strategically aligned.

Fill in the blank: Strategic models in marketing help balance short-term gains with long-term _____.

Box 4.3 Strategic planning applications in marketing

- Multi-year campaigns
- Competitive pricing
- Product launch coordination

Figure 4.3 Nionnelar programming in pricing and demand analysis

Pilot questions 4.3

1. What is nonlinear programming and why is it important in pricing analysis?
2. Give one example of a nonlinear relationship in marketing.
3. Define Nash equilibrium in the context of competitive behaviour.
4. Mention one application of game theory in marketing.
5. How do strategic models support long-term marketing planning?

4.4 Advanced Case Applications and Limitations

4.4.1 Case study: advertising strategy optimisation

Mathematical programming can be applied to optimise advertising strategies by determining the best allocation of funds across multiple channels. Using linear programming, managers can maximise reach or profit while respecting budget constraints.

For example, a company may model the effectiveness of TV, radio, and online ads, then use LP to identify the optimal mix that maximises consumer engagement.

Fill in the blank: Linear programming can be used to optimise _____ strategies by allocating funds across channels.

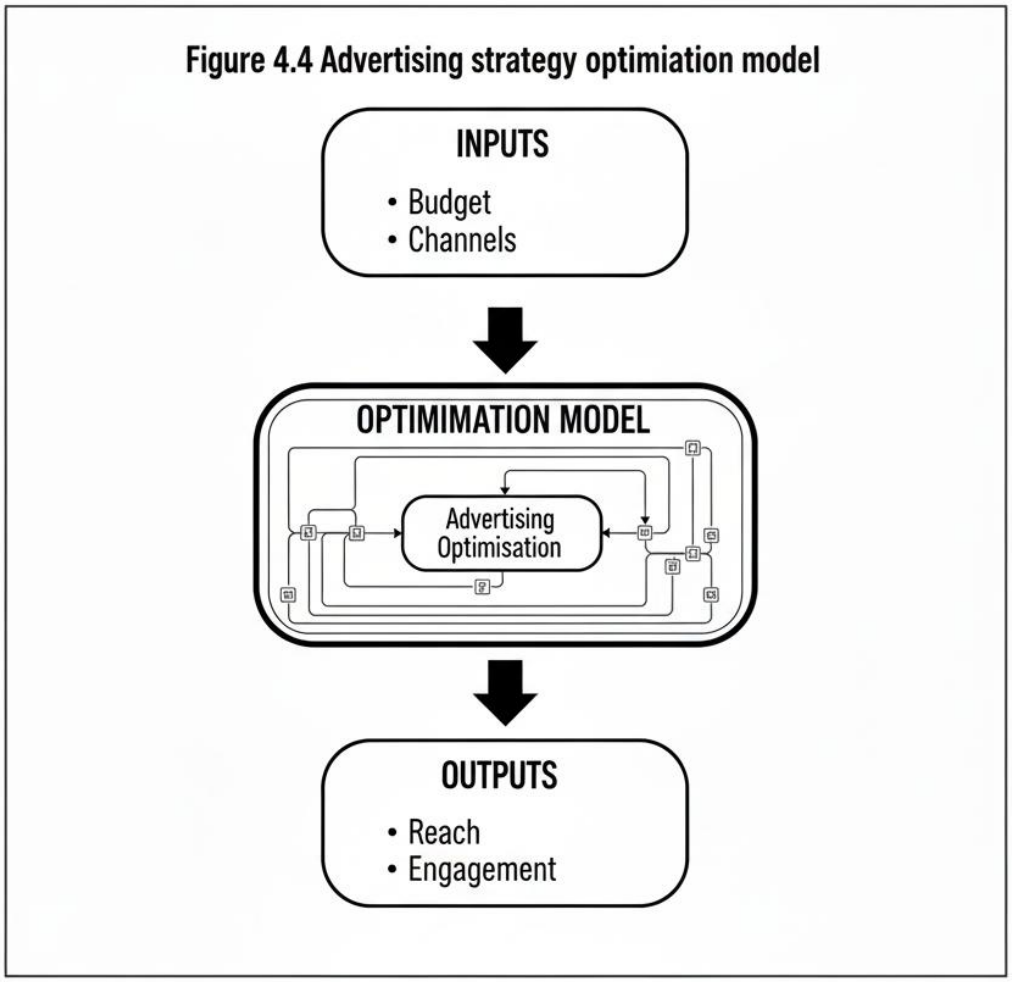


Figure 4.4 Product launch simulation model

4.4.2 Case study: distribution and logistics planning

Integer programming is often applied to distribution and logistics planning. It helps managers decide on warehouse locations, delivery routes, and inventory levels to minimise costs and improve efficiency.

For instance, a logistics company may use IP to select the best combination of warehouse sites that reduces transportation costs while meeting customer demand.

Fill in the blank: Integer programming is often applied to _____ planning to minimise costs and improve efficiency.

Table 4.4 Distribution and logistics planning case study

Decision Variables	Outcomes
• Warehouse sites • Warehouse sites • Delivery routes • Inventory levels	• Cost reduction • Efficiency improvement

Figure 4.4 Product launch simulation model

4.4.3 Limitations and practical considerations of mathematical programming

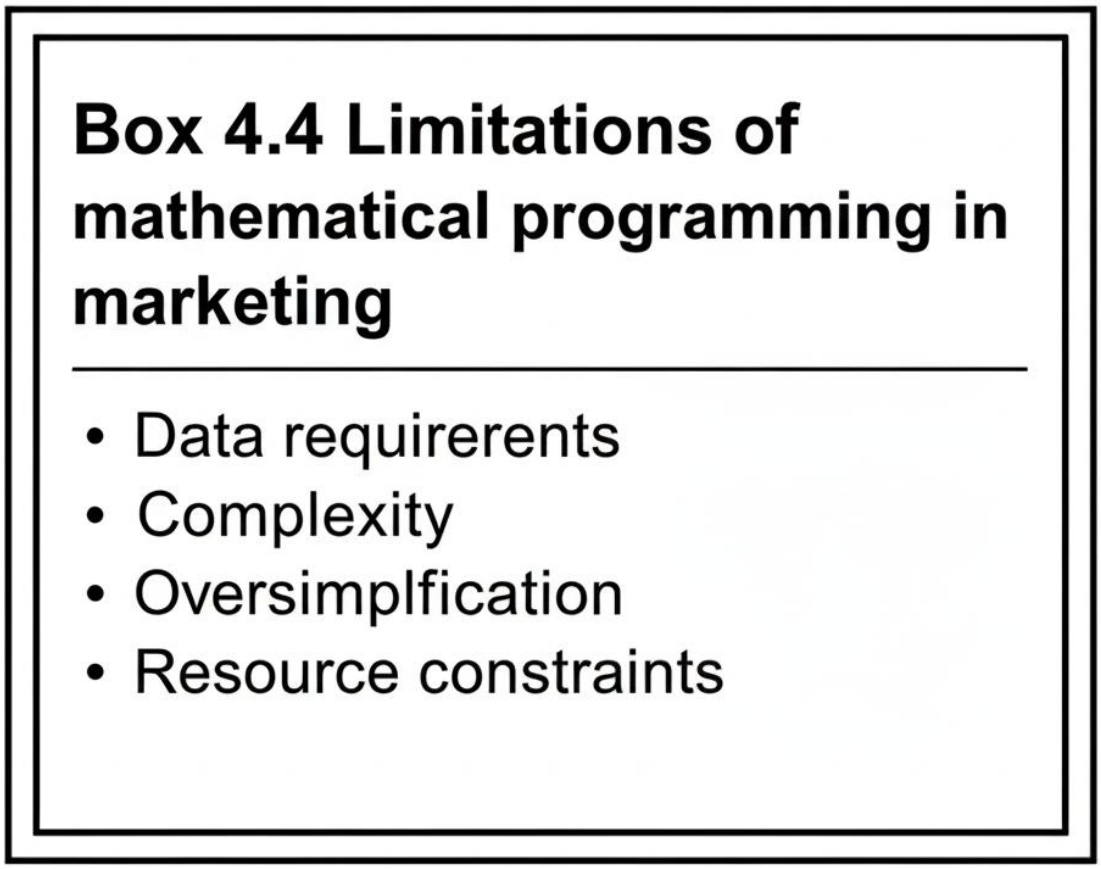
Despite its usefulness, mathematical programming has limitations.

- **Data requirements**: Models depend on accurate and complete data, which may be difficult to obtain.
- **Complexity**: Advanced models can be difficult to build and interpret without specialised expertise.
- **Oversimplification**: Models may ignore qualitative factors such as consumer psychology or brand reputation.
- **Resource constraints**: Implementing solutions may require computing power and skilled personnel.

Managers must balance the insights from mathematical programming with practical realities and managerial judgement.

Fill in the blank: One limitation of mathematical programming is that models may ignore qualitative factors such as _____ psychology.

Figure 4.4 Product launch simulation model



Pilot questions 4.4

1. How can mathematical programming optimise advertising strategies?
2. What type of programming is often applied to distribution and logistics planning?
3. Mention one decision variable in a logistics planning model.
4. What is one limitation of mathematical programming in marketing?
5. Why must managers balance programming insights with managerial judgement?

Series Summary

This Series introduced advanced mathematical programming and strategic models for marketing decision analysis. The purpose was to show how managers can use optimisation techniques and strategic frameworks to make evidence-based decisions in complex, competitive environments.

We began with the concept and types of mathematical programming, then explored linear and integer programming applications in resource allocation, product mix, and discrete decisions. Next, we examined nonlinear programming and strategic models, including game theory and Nash equilibrium, to analyse competitive behaviour. Finally, we considered advanced case applications such as advertising optimisation and logistics planning, while also highlighting limitations and practical considerations. By completing this Series, you should now be able to define mathematical programming, apply LP, IP, and NLP methods, interpret strategic models, and evaluate their applications and limitations in marketing contexts.

Glossary of Terms

- **Advertising optimisation**: Using mathematical programming to allocate funds across channels for maximum impact.
- **Integer programming (IP)**: A model where decision variables must take whole numbers, useful for discrete decisions.
- **Linear programming (LP)**: A model with linear objectives and constraints, used for resource allocation and product mix.
- **Mathematical programming**: The use of mathematical models and optimisation techniques to solve decision problems.
- **Nash equilibrium**: A situation in game theory where no competitor benefits from changing strategy unilaterally.
- **Nonlinear programming (NLP)**: A model with nonlinear objectives or constraints, often applied to pricing and demand analysis.
- **Resource allocation**: Distributing limited resources such as advertising budgets or production capacity.
- **Strategic models**: Analytical frameworks for studying competitive behaviour and long-term planning.
- **Facility location**: A discrete decision problem solved using integer programming to minimise distribution costs.
- **Oversimplification**: A limitation of mathematical programming where qualitative factors are ignored.

Concept Check Questions [Series 4]

Objective questions

1. Define mathematical programming in marketing decision analysis. (Linked to SLO 4.1)
2. Name the three types of mathematical programming models discussed in this Series. (Linked to SLO 4.1)

3. Which type of programming is used for discrete decisions such as media selection? (Linked to SLO 4.3)
4. What is nonlinear programming used for in marketing? (Linked to SLO 4.4)
5. Define Nash equilibrium in the context of competitive behaviour. (Linked to SLO 4.5)

Short-answer questions

6. Explain one application of linear programming in marketing. (Linked to SLO 4.2)
7. Give one example of how integer programming can be applied to logistics. (Linked to SLO 4.2)
8. Describe one limitation of mathematical programming in marketing. (Linked to SLO 4.6)

Long-answer questions

9. Analyse the role of linear and integer programming in marketing optimisation, providing examples. (Linked to SLO 4.2, SLO 4.3)
10. Evaluate the importance of strategic models such as game theory and Nash equilibrium in competitive marketing environments. (Linked to SLO 4.5)

Answers to Concept Check Questions [Series 4]

Objective questions

1. Mathematical programming uses mathematical models and optimisation techniques to solve decision problems with constraints.
2. Linear programming, integer programming, nonlinear programming.
3. Integer programming.
4. Pricing and demand analysis.
5. A situation where no competitor benefits from changing strategy unilaterally.

Short-answer questions

6. LP can be used to allocate advertising budgets across channels to maximise reach.
7. IP can be applied to warehouse location decisions to minimise distribution costs.
8. One limitation is oversimplification, where models ignore qualitative factors like consumer psychology.

Long-answer questions

9. **Basic response**: LP optimises continuous resource allocation, while IP handles discrete decisions. Examples include advertising allocation (LP) and facility location (IP). **Value-added response**: Together, LP and IP provide a comprehensive toolkit for marketing optimisation. LP ensures efficient use of continuous resources, while IP addresses discrete, real-world constraints. Their combined use enhances both tactical and strategic decision-making.

10. **Basic response**: Strategic models such as game theory and Nash equilibrium help managers anticipate competitor actions. **Value-added response**: These models are crucial in competitive environments where firms must design strategies resilient to rival behaviour. For example, Nash equilibrium explains stable pricing strategies, while game theory supports advertising competition analysis. Their application strengthens long-term strategic planning.

Answers to Pilot Questions [Series 4]

Part 4.1

1. Mathematical programming uses mathematical models and optimisation techniques to solve decision problems.
2. Linear, integer, nonlinear programming.
3. Integer programming.
4. Optimising advertising budgets.
5. Pricing strategies.

Part 4.2

1. To optimise resource allocation and product mix.
2. Integer programming.
3. Allocating advertising budgets across channels.
4. Facility location.
5. To demonstrate practical applications of LP and IP.

Part 4.3

1. NLP is used when objectives or constraints are nonlinear, important for pricing analysis.
2. Price-demand relationships.
3. A situation where no competitor benefits from changing strategy unilaterally.
4. Pricing wars.
5. By balancing short-term gains with long-term sustainability.

Part 4.4

1. By determining the best allocation of funds across advertising channels.
2. Integer programming.
3. Warehouse site selection.
4. Oversimplification.
5. Because qualitative factors and managerial judgement must complement quantitative insights.

Series 5: Advanced OR Techniques in Inventory and Project Management

Series Outline

- **Part 5.1 Advanced Inventory Models**
  - 5.1.1 Deterministic inventory models (EOQ, reorder point)
  - 5.1.2 Probabilistic inventory models (safety stock, service levels)
  - 5.1.3 Multi-item and multi-echelon inventory systems
- **Part 5.2 Dynamic and Stochastic Inventory Control**
  - 5.2.1 Dynamic lot-sizing models
  - 5.2.2 Stochastic demand and lead time models
  - 5.2.3 Simulation approaches to inventory control
- **Part 5.3 Project Scheduling and Control Techniques**
  - 5.3.1 Critical Path Method (CPM)
  - 5.3.2 Programme Evaluation and Review Technique (PERT)
  - 5.3.3 Resource-constrained project scheduling
- **Part 5.4 Case Applications in Inventory and Project Management**
  - 5.4.1 Case study: retail inventory optimisation
  - 5.4.2 Case study: manufacturing supply chain inventory control
  - 5.4.3 Case study: marketing campaign project scheduling

Introduction

In the previous Series, we explored mathematical programming and strategic models, focusing on optimisation and competitive behaviour. This Series shifts attention to **advanced operational research (OR) techniques in inventory and project management**, two critical areas where efficiency and foresight directly impact marketing success.

Inventory management ensures that products are available to meet customer demand without incurring excessive costs, while project management provides the tools to plan, schedule, and control marketing initiatives. Advanced OR techniques such as deterministic and probabilistic inventory models, dynamic and stochastic control, and project scheduling methods (CPM and PERT) allow managers to make better decisions under uncertainty and resource constraints.

The aim of this Series is to equip you with advanced tools for managing inventory systems and marketing projects. By the end, you will be able to apply deterministic and probabilistic models, use dynamic and stochastic approaches, implement project scheduling techniques, and analyse case applications in retail, supply chain, and campaign management.

Series Learning Outcomes

Upon completing this Series, you should be able to:

- **5.1** explain advanced inventory models including deterministic, probabilistic, and multi-echelon systems,
- **5.2** apply dynamic and stochastic inventory control techniques to marketing and supply chain problems,
- **5.3** demonstrate project scheduling and control methods such as CPM and PERT,
- **5.4** analyse case applications of inventory optimisation and project management in marketing contexts, and
- **5.5** evaluate the limitations and practical considerations of advanced OR techniques in inventory and project management.

5.1 Advanced Inventory Models

5.1.1 Deterministic inventory models

Deterministic inventory models assume demand and lead time are known with certainty. The most common is the **Economic Order Quantity (EOQ)** model, which determines the optimal order size that minimises total inventory costs (ordering + holding). Another is the **Reorder Point (ROP)** model, which specifies the inventory level at which a new order should be placed to avoid stockouts.

Fill in the blank: The EOQ model determines the optimal _____ size that minimises total inventory costs.

Figure 5.1 Economic Order Quantity model

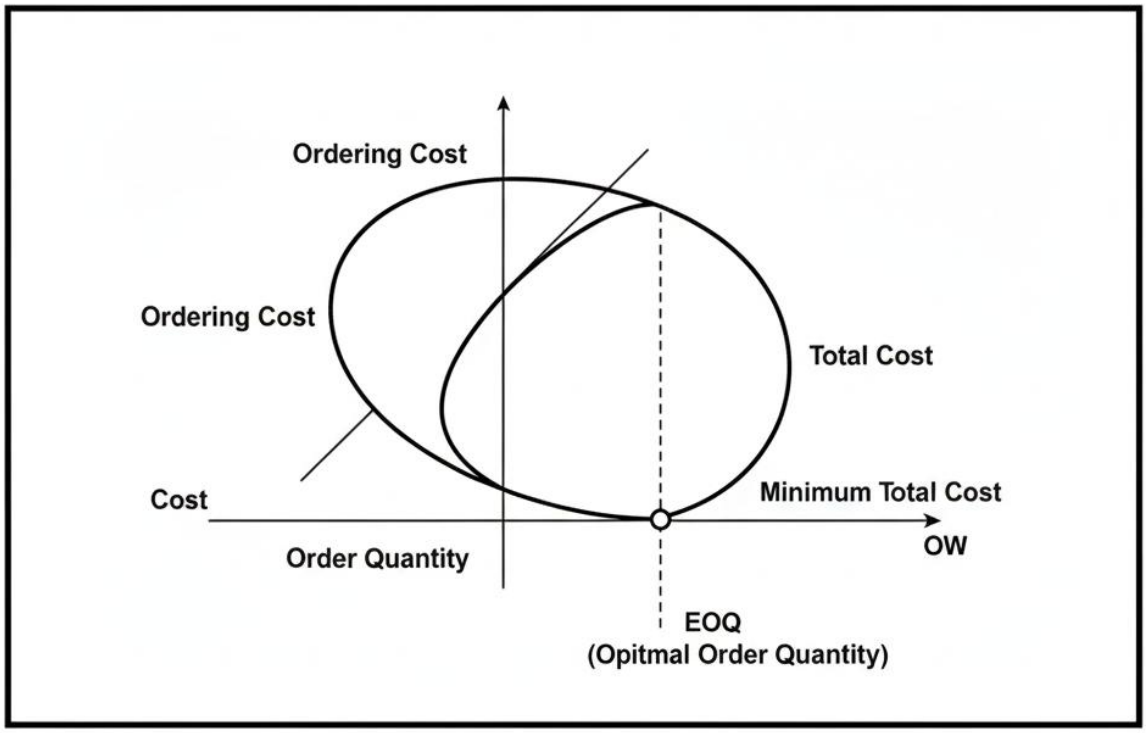


Figure 4.4 Advertising strategy optimization model

5.1.2 Probabilistic inventory models

Probabilistic models account for uncertainty in demand and lead time. They introduce concepts such as **safety stock** (extra inventory held to protect against variability) and **service levels** (probability of meeting demand without stockouts).

For example, a retailer may hold safety stock to ensure a 95% service level, meaning demand is met 95% of the time.

Fill in the blank: Probabilistic inventory models introduce the concept of _____ stock to protect against variability.

Table 5.1 Proboblastic inventory models and key concepts

Model Type	Key Concepts
Deterninatic Models	• Constant demand & lead time • No stockouts (idealizzed) Basic EOQ, ROP
Proboblastic Models	• Variable demand & leate • Balances costs with service level • Service Level (fill rate)

Figure 5.1 Economic Order Quantity model

5.1.3 Multi-item and multi-echelon inventory systems

Advanced inventory models also consider multiple items and multiple levels (echelons) in the supply chain.

- **Multi-item models**: Optimise inventory across several products simultaneously, considering shared resources.
- **Multi-echelon models**: Coordinate inventory decisions across different stages of the supply chain (e.g., suppliers, warehouses, retailers).

These models are crucial for complex supply chains where interdependencies must be managed to minimise costs and maximise service.

Fill in the blank: Multi-echelon inventory models coordinate decisions across different stages of the _____ chain.

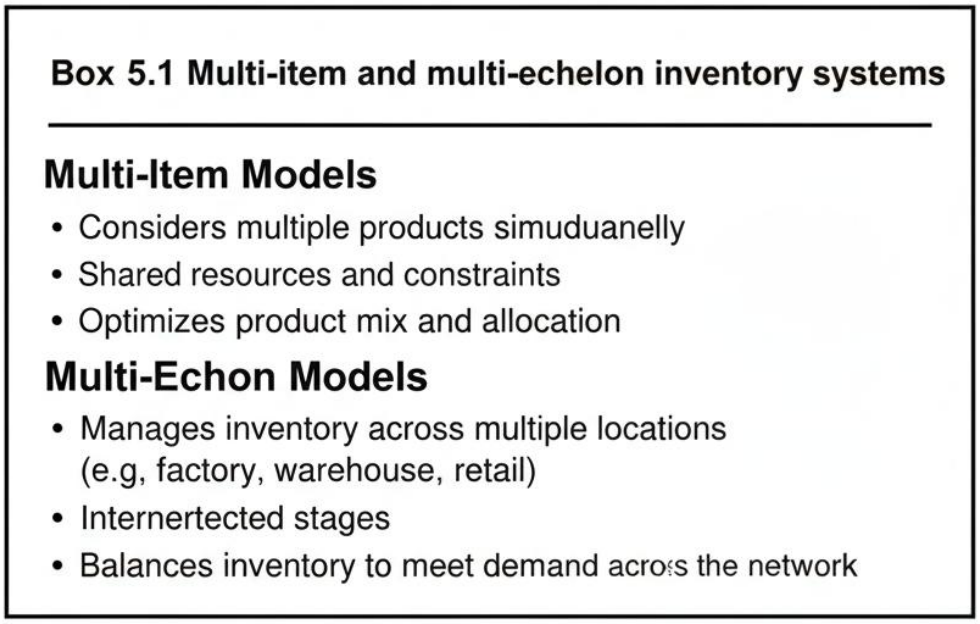


Figure 5.1 Economic Order Quantity model

Pilot questions 5.1

1. What is the EOQ model and what does it determine?
2. Define the concept of reorder point (ROP).
3. What is safety stock and why is it important?
4. Explain the meaning of service level in probabilistic inventory models.
5. What is the difference between multi-item and multi-echelon inventory systems?

5.2 Dynamic and Stochastic Inventory Control

5.2.1 Dynamic lot-sizing models

Dynamic lot-sizing models extend deterministic approaches by considering inventory decisions over multiple time periods. Unlike EOQ, which assumes constant demand, dynamic models allow demand to vary across periods. Techniques such as the **Wagner-Whitin algorithm** help managers determine optimal order quantities for each period, balancing ordering and holding costs.

Fill in the blank: Dynamic lot-sizing models allow demand to vary across different _____ periods.

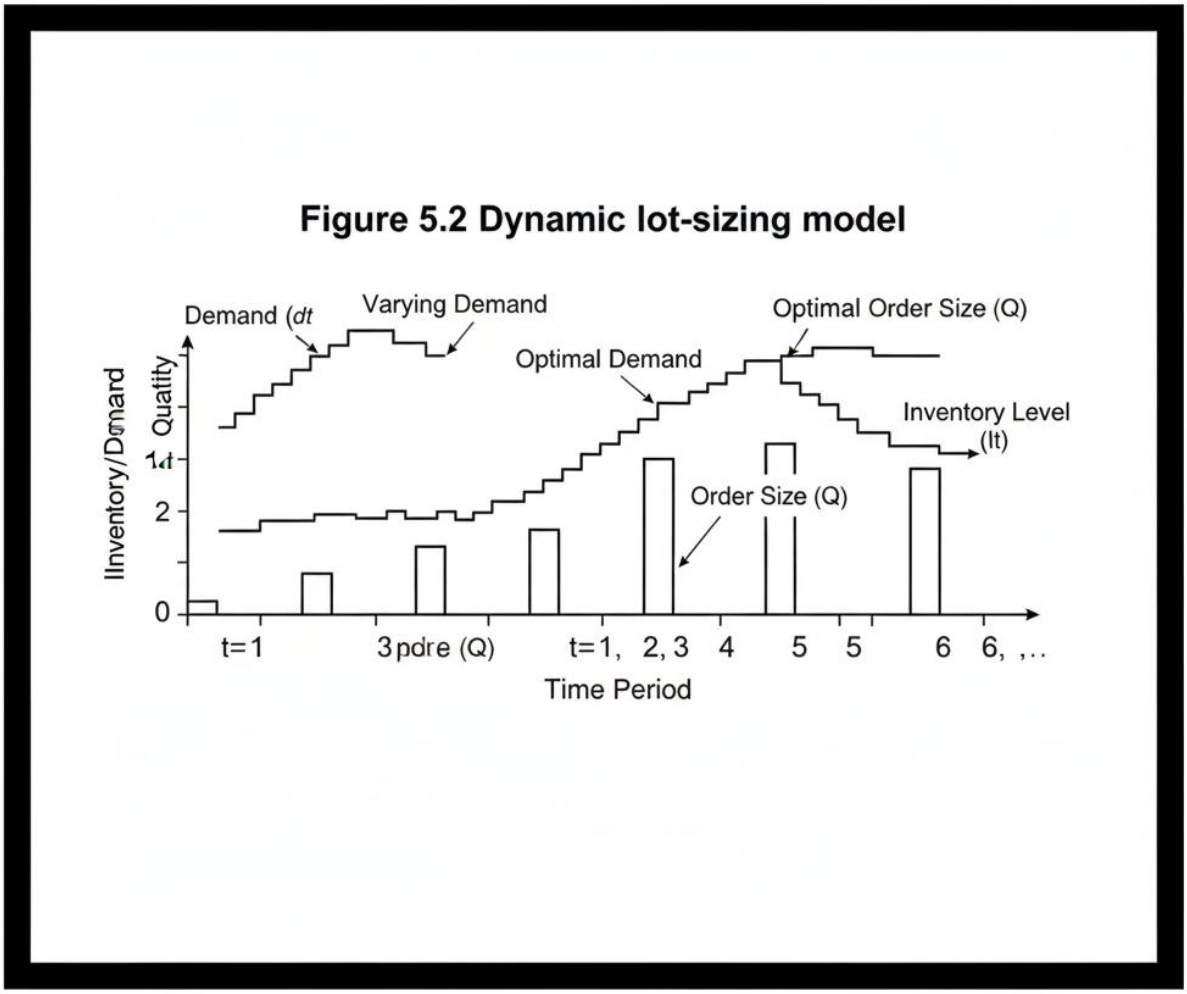


Figure 5.1 Economic Order Quantity model

5.2.2 Stochastic demand and lead time models

Stochastic models incorporate randomness in demand and lead time. These models use probability distributions to represent uncertainty and help managers design policies that minimise expected costs.

For example, a stochastic model may use a normal distribution to represent demand variability, allowing managers to calculate optimal safety stock levels.

Fill in the blank: Stochastic inventory models use probability _____ to represent uncertainty in demand and lead time.

Table 5.2 Stoshoic inventory models and key features

	Key Features & Applications
Stochatic Demand	• Variable customer demand • Forecast uncertainty • Safety stock to prevent stockouts • Service level optimization
Stochatic Lead Time	• Variable time to receive orders • Supplier delays • Higher safety stock requirements • Dynamic reorder points

Figure 5.2 Dynamic lot-sizing model

5.2.3 Simulation approaches to inventory control

Simulation is often used to evaluate inventory policies under uncertainty. By generating random demand and lead time scenarios, managers can test how different policies perform in terms of cost, service level, and stockouts.

Simulation provides insights into the robustness of inventory strategies and helps managers choose policies that perform well under a variety of conditions.

Fill in the blank: Simulation approaches to inventory control generate random _____ and lead time scenarios to test policies.

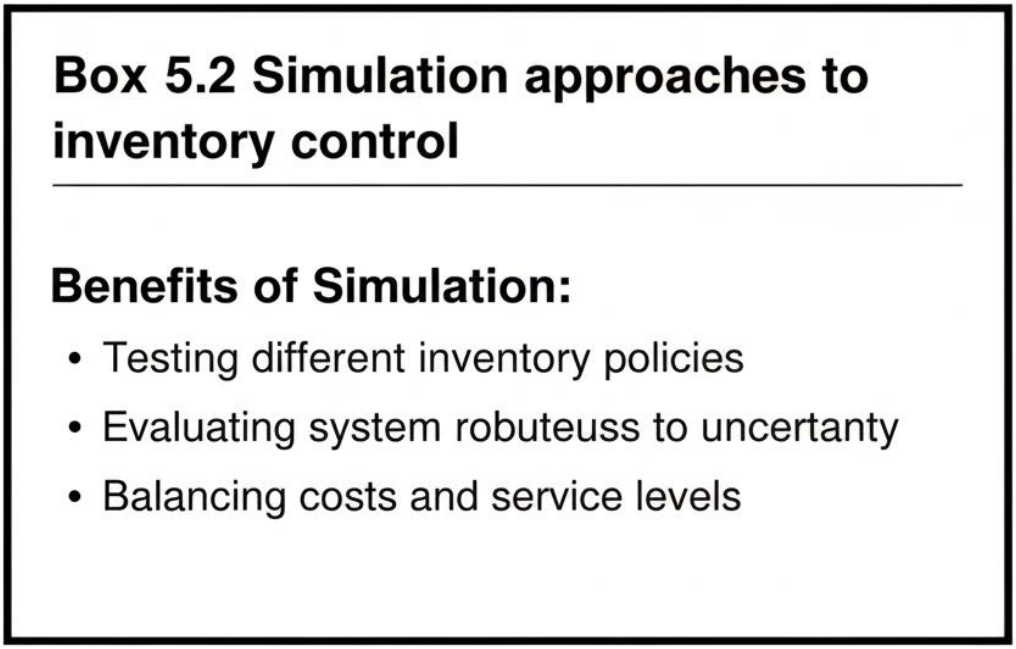


Figure 5.2 Dynamic lot-sizing model

Pilot questions 5.2

1. What is the purpose of dynamic lot-sizing models?
2. Which algorithm is commonly used in dynamic lot-sizing?

3. How do stochastic models represent uncertainty in demand and lead time?
4. Give one example of how simulation can be applied to inventory control.
5. Why are simulation approaches valuable in evaluating inventory policies?

5.3 Project Scheduling and Control Techniques

5.3.1 Critical Path Method (CPM)

The **Critical Path Method (CPM)** is a project scheduling technique used to identify the longest path of dependent activities in a project. This path determines the minimum project duration. Activities on the critical path have zero slack, meaning any delay will directly delay the project completion.

In marketing, CPM can be applied to campaign planning, product launches, or event organisation, ensuring that critical tasks are prioritised to meet deadlines.

Fill in the blank: The critical path represents the _____ project duration and includes activities with zero slack.

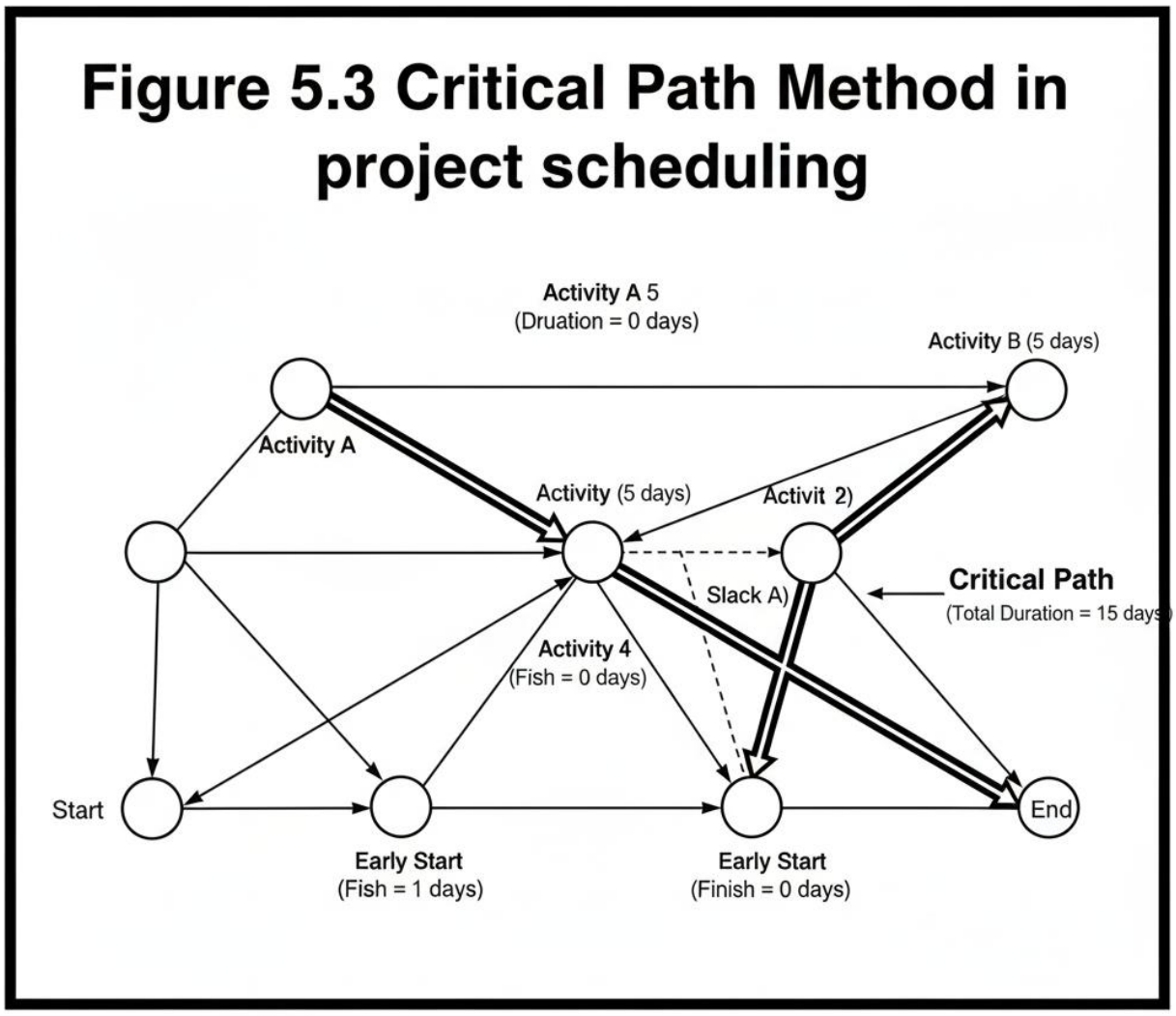


Figure 5.2 Dynamic lot-sizing model

5.3.2 Programme Evaluation and Review Technique (PERT)

PERT is a project management tool that incorporates uncertainty by using three time estimates for each activity: optimistic, most likely, and pessimistic. These estimates are used to calculate expected activity durations and project completion time.

PERT is especially useful in marketing projects where task durations are uncertain, such as creative design or market research.

Fill in the blank: PERT uses three time estimates for each activity: optimistic, most likely, and _____.

Table 5.3 PERT time estimates and calculations

Concept	Description/Formula
Time Estimate Type	• Optimistic Time (a) • Most Likely Time (m) • Pessistmic Time (b)
Expected Duration (E)	$E = (a + 4m + b)\ \frac{1}{6}$
Variance (V)	$V = ((b - a\ \frac{1}{6}\ 6^2$
Standard Devation (σ	$\sigma = \overline{sqr}(V)$

Figure 5.3 Critical Path Method in project scheduling

5.3.3 Resource-constrained project scheduling

In reality, projects often face resource limitations such as budget, manpower, or equipment. **Resource-constrained scheduling** adjusts project plans to account for these limitations, sometimes extending project duration but ensuring feasibility.

For example, a marketing campaign may need to be rescheduled if limited staff are available to handle multiple tasks simultaneously.

Fill in the blank: Resource-constrained scheduling adjusts project plans to account for limitations in _____ or manpower.

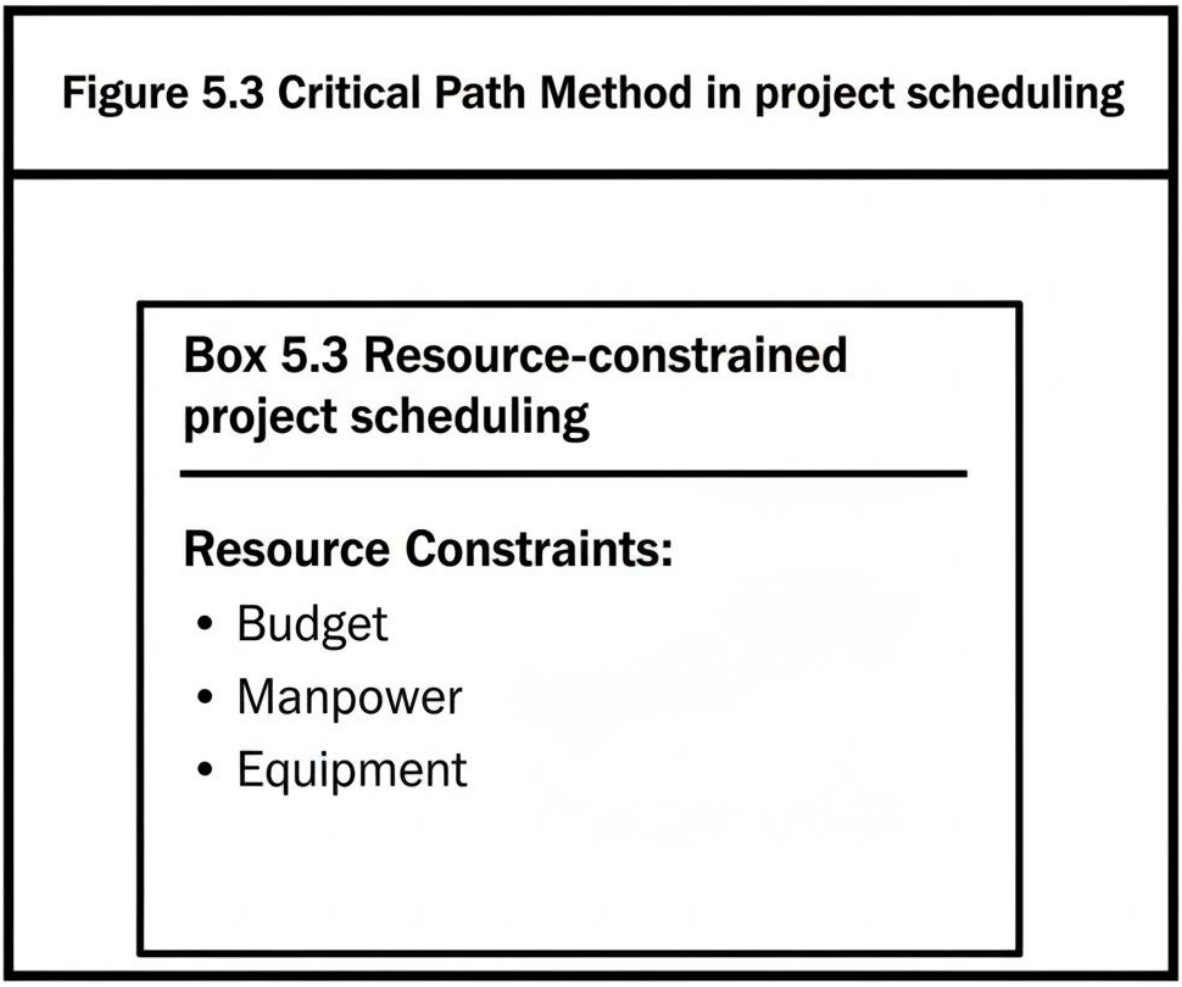


Figure 5.3 Critical Path Method in project scheduling

Pilot questions 5.3

1. What is the purpose of the Critical Path Method (CPM)?
2. Which activities have zero slack in CPM?
3. What are the three time estimates used in PERT?
4. Why is PERT useful in marketing projects?
5. What does resource-constrained scheduling account for in project planning?

5.4 Case Applications in Inventory and Project Management

5.4.1 Case study: retail inventory optimisation

Retailers often face the challenge of balancing product availability with minimising holding costs. Advanced inventory models such as EOQ and probabilistic approaches are applied to determine optimal order quantities and safety stock levels.

For example, a supermarket chain may use probabilistic models to maintain a 95% service level for fast-moving consumer goods, ensuring customer satisfaction while avoiding excess stock.

Fill in the blank: Retailers use probabilistic inventory models to maintain desired _____ levels and avoid stockouts.

Figure 5.4 Retail inventory optimiation case

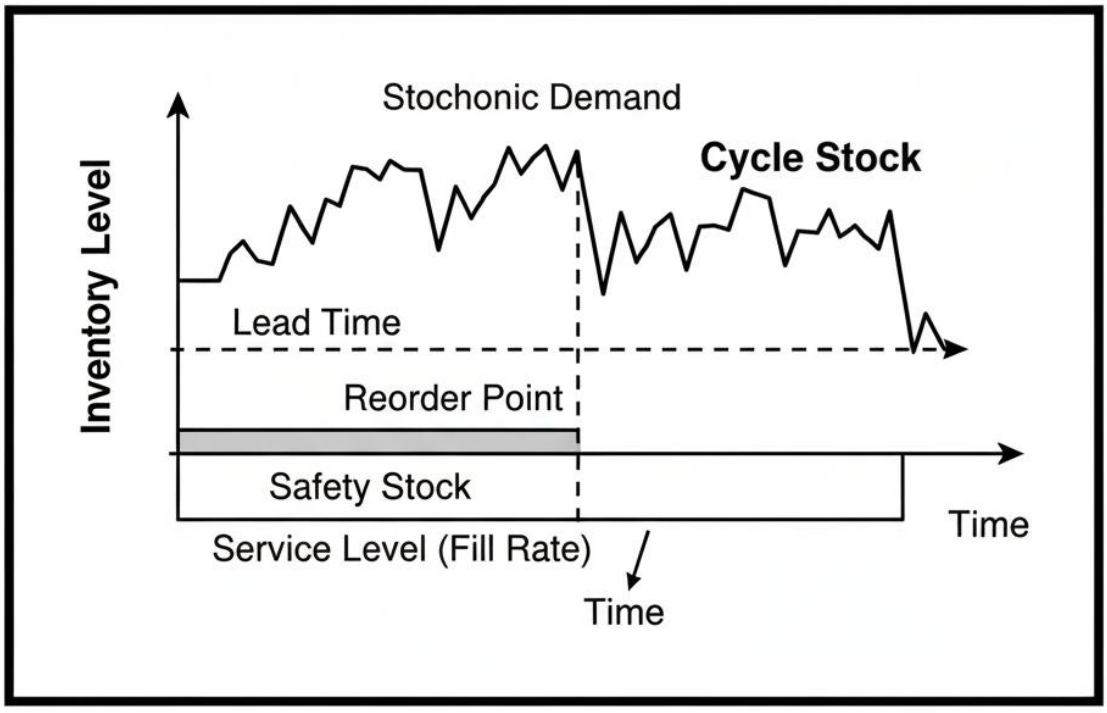


Figure 5.3 Critical Path Method in project scheduling

5.4.2 Case study: manufacturing supply chain inventory control

Manufacturers often manage complex supply chains with multiple items and echelons. Multi-echelon inventory models are applied to coordinate decisions across suppliers, warehouses, and retailers.

For instance, a manufacturing company may use dynamic lot-sizing and stochastic models to optimise raw material orders and finished goods distribution, reducing costs while maintaining service levels.

Fill in the blank: Multi-echelon inventory models coordinate inventory decisions across suppliers, warehouses, and _____.

Table 5.4 Manufacturing supply chain inventory control case

Supply Chain Stages	Outcomes
• Suppliers • Manufacturing • Warehouses • Retailers	• Cost reduction • Efficiency improvement • Customer service improvement

Figure 5.4 Retail inventory optimation case

5.4.3 Case study: marketing campaign project scheduling

Marketing campaigns often involve multiple tasks with interdependencies and resource constraints. CPM and PERT are applied to schedule tasks, identify critical paths, and estimate completion times.

For example, a company launching a new product may use PERT to estimate campaign duration, accounting for uncertainties in creative design and media production. Resource-constrained scheduling ensures tasks are feasible given staff and budget limits.

Fill in the blank: CPM identifies the critical path, while PERT incorporates _____ in activity durations.

Table 5.4 Manufacturing supply chain inventory control case

Supply Chain Stages	Outcomes
• Suppliers • Manufacturing • Warehouses • Retailers	• Cost reduction • Efficiency improvement • Customer service improvement

Figure 5.4 Retail inventory optimation case

Pilot questions 5.4

1. How can inventory optimisation improve retail operations?

2. What is the role of multi-echelon models in manufacturing supply chains?
3. Which supply chain stages are coordinated in multi-echelon inventory models?
4. How does PERT differ from CPM in project scheduling?
5. Why is resource-constrained scheduling important in marketing campaigns?

Series Summary

This Series introduced advanced operational research (OR) techniques for inventory and project management, two areas critical to marketing success. We began with deterministic and probabilistic inventory models, including EOQ, reorder point, safety stock, and service levels. Next, we explored dynamic and stochastic inventory control, highlighting lot-sizing, probability-based models, and simulation approaches. We then examined project scheduling techniques such as CPM, PERT, and resource-constrained scheduling. Finally, we analysed case applications in retail inventory optimisation, manufacturing supply chain control, and marketing campaign scheduling.

By completing this Series, you should now be able to explain advanced inventory models, apply dynamic and stochastic control, demonstrate project scheduling methods, analyse case applications, and evaluate limitations and practical considerations.

Glossary of Terms

- **Economic Order Quantity (EOQ)**: A deterministic model that calculates the optimal order size to minimise total inventory costs.
- **Reorder Point (ROP)**: The inventory level at which a new order should be placed to avoid stockouts.
- **Safety stock**: Extra inventory held to protect against demand or lead time variability.
- **Service level**: The probability of meeting demand without stockouts.
- **Dynamic lot-sizing**: Inventory models that allow demand to vary across multiple time periods.
- **Stochastic models**: Models that incorporate randomness in demand and lead time using probability distributions.
- **Simulation in inventory control**: Testing inventory policies under random demand and lead time scenarios.
- **Critical Path Method (CPM)**: A project scheduling technique that identifies the longest path of dependent activities.
- **Programme Evaluation and Review Technique (PERT)**: A project scheduling tool that uses three time estimates to account for uncertainty.
- **Resource-constrained scheduling**: Adjusting project plans to account for limitations in budget, manpower, or equipment.

Concept Check Questions [Series 5]

Objective questions

1. What does the EOQ model determine? (Linked to SLO 5.1)
2. Define the concept of reorder point (ROP). (Linked to SLO 5.1)
3. What is safety stock used for in inventory management? (Linked to SLO 5.1)
4. Which algorithm is commonly used in dynamic lot-sizing? (Linked to SLO 5.2)
5. What are the three time estimates used in PERT? (Linked to SLO 5.3)

Short-answer questions

6. Explain the meaning of service level in probabilistic inventory models. (Linked to SLO 5.1)

7. Give one example of how simulation can be applied to inventory control. (Linked to SLO 5.2)

8. Why is resource-constrained scheduling important in project management? (Linked to SLO 5.3)

Long-answer questions

9. Analyse the differences between deterministic and probabilistic inventory models, providing examples. (Linked to SLO 5.1)

10. Evaluate the role of CPM and PERT in marketing campaign scheduling, highlighting their strengths and limitations. (Linked to SLO 5.3, SLO 5.4)

Answers to Concept Check Questions [Series 5]

Objective questions

1. The EOQ model determines the optimal order size that minimises total inventory costs.
2. ROP is the inventory level at which a new order should be placed to avoid stockouts.
3. Safety stock protects against variability in demand and lead time.
4. The Wagner-Whitin algorithm.
5. Optimistic, most likely, pessimistic.

Short-answer questions

6. Service level is the probability of meeting demand without stockouts.

7. Simulation can test how different inventory policies perform under random demand scenarios.

8. Resource-constrained scheduling ensures project feasibility when resources such as manpower or budget are limited.

Long-answer questions

9. **Basic response**: Deterministic models assume certainty in demand and lead time, while probabilistic models account for variability. EOQ and ROP are deterministic, while safety stock and service levels are probabilistic. **Value-added response**: Probabilistic models provide more realistic insights in uncertain environments, but deterministic models are simpler and easier to implement. Managers often combine both approaches to balance simplicity and accuracy.

10. **Basic response**: CPM identifies the critical path and minimum project duration, while PERT incorporates uncertainty in activity durations. **Value-added response**: CPM is useful for projects with well-defined tasks, while PERT is better suited for uncertain environments like marketing campaigns. Together, they provide complementary insights, helping managers plan realistically while maintaining control over deadlines.

Answers to Pilot Questions [Series 5]

Part 5.1

1. EOQ determines optimal order size.
2. ROP is the inventory level for placing new orders.
3. Safety stock is extra inventory to protect against variability.
4. Service level is the probability of meeting demand without stockouts.
5. Multi-item models optimise across products; multi-echelon models coordinate across supply chain stages.

Part 5.2

1. To optimise inventory decisions across multiple time periods.
2. Wagner-Whitin algorithm.
3. By using probability distributions.
4. Testing policies under random demand and lead time scenarios.
5. They show robustness of policies under uncertainty.

Part 5.3

1. To identify the longest path of dependent activities.
2. Activities on the critical path.
3. Optimistic, most likely, pessimistic.
4. Because it accounts for uncertainty in task durations.
5. To ensure feasibility under limited resources.

Part 5.4

1. By balancing product availability with minimising holding costs.
2. To coordinate inventory decisions across supply chain stages.

3. Suppliers, warehouses, retailers.
4. PERT incorporates uncertainty in activity durations.
5. To ensure tasks are feasible given staff and budget limits.