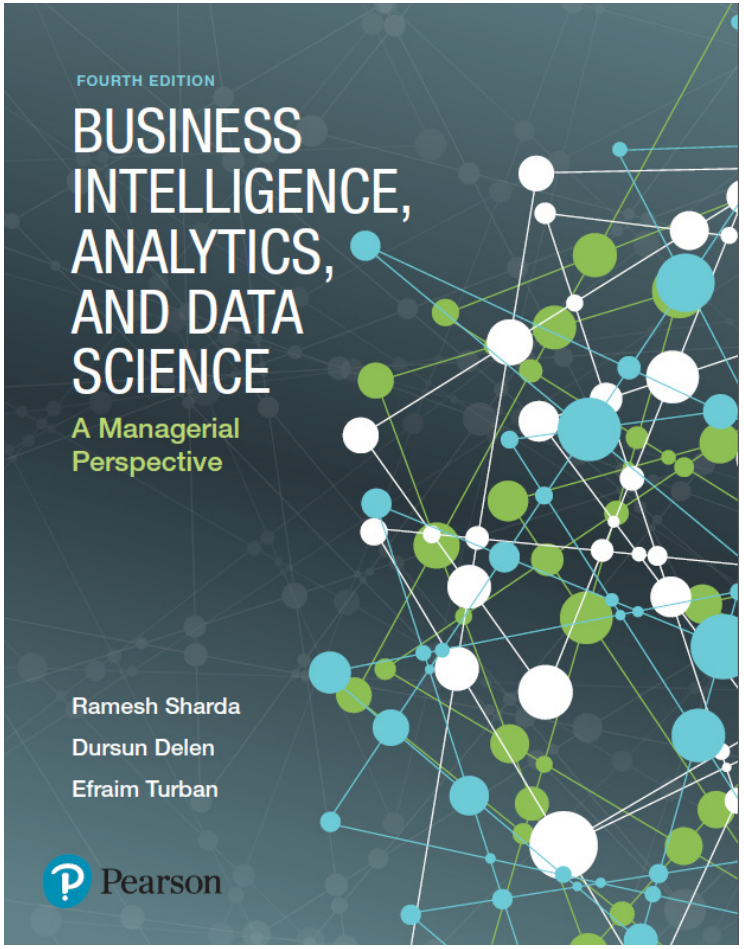
Business Intelligence, Analytics, and Data Science: A Managerial Perspective

Fourth Edition



Chapter 6 – Part A

Prescriptive Analytics: Optimization and Simulation

Pearson

Learning Objectives (1 of 2)

6.1 Understand the applications of prescriptive analytics techniques in combination with reporting and predictive analytics

6.2 Understand the basic concepts of analytical decision modeling

6.3 Understand the concepts of analytical models for selected decision problems, including linear programming and simulation models for decision support

6.4 Describe how spreadsheets can be used for analytical modeling and solutions

Learning Objectives (2 of 2)

6.5 Explain the basic concepts of optimization and when to use them

6.6 Describe how to structure a linear programming model

6.7 Explain what is meant by sensitivity analysis, what-if analysis, and goal seeking

6.8 Understand the concepts and applications of different types of simulation

6.9 Understand potential applications of discrete event simulation

OPENING VIGNETTE School District of Philadelphia Uses Prescriptive Analytics to Find Optimal Solution for Awarding Bus Route Contracts

Discussion Questions

1. What decision was being made in this vignette?
2. What data (descriptive and or predictive) might one need to make the best allocations in this scenario?
3. What other costs or constraints might you have to consider in awarding contracts for such routes?
4. Which other situations might be appropriate for applications of such models?

Model-Based Decision Making

- Prescriptive analytics – making decision using some kind of analytical model
  - Descriptive and predictive analytics creates the foundation (i.e., choice alternatives) for prescriptive analytics (i.e., making best possible decision)
- Descriptive and Predictive leads to Prescriptive
  - Descriptive, Predictive → Prescriptive
- Example
  - Profit maximization based on optimal spending on promotions and product/service pricing

Prescriptive Analytics Model Examples

- INFORMS publications such as *Interfaces*, *ORMS Today*, and *Analytics Magazine*, include real-world cases illustrating successful analytics applications.
- Modeling is a key element to prescriptive analytics
  - Mathematical modeling
- TurboRouter - DSS for ship routing
  - In just a few weeks, company saved $1-2M
- Example: which customers should receive certain promotional offers to maximize overall response (while staying within a pre-specified budget).

Application Case 6.1

Optimal Transport for ExxonMobil Downstream through a Decision Support System (DSS)

Questions for Discussion

1. List three ways in which manual scheduling of ships could result in more operational costs as compared to the tool developed.
2. In what other ways can ExxonMobil leverage the decision support tool developed to expand and optimize their other business operations?
3. What are some strategic decisions that could be made by decision makers using the tool developed?

Major Modeling Issues

- Problem identification and environmental analysis (information collection)
- Variable identification
  - Influence diagrams, cognitive maps
- Forecasting (predictive analytics)
  - More information leads to better forecast/prediction
- Multiple models: A decision system can include several models, each of which representing a different part of the decision-making problem
  - Static versus dynamic models
  - See categories of models in the next slide

Major Modeling Issues

- Model Management
  - Models (like data) must be managed to maintain their integrity and applicability
  - Model-based management systems (MBMS)
- Knowledge-Based Modeling (KBM)
  - DSS usually uses quantitative models
  - Expert systems use qualitative, KB models
- Current trends in modeling
  - Cloud-based modeling tools (efficient and cost effective)
  - Transparent models (multidimensional/visual models)
  - Model of models
    - e.g., Influence Diagrams (to build and solve models)

Categories of Models

TABLE 6.1 Categories of Models

Category	Process and Objective	Representative Techniques
Optimization of problems with few alternatives	Find the best solution from a small number of alternatives	Decision tables, decision trees, analytic hierarchy process
Optimization via algorithm	Find the best solution from a large number of alternatives, using a step-by-step improvement process	Linear and other mathematical programming models, network models
Optimization via an analytic formula	Find the best solution in one step, using a formula	Some inventory models
Simulation	Find a good enough solution or the best among the alternatives checked, using experimentation	Several types of simulation
Heuristics	Find a good enough solution, using rules	Heuristic programming, expert systems
Predictive models	Predict the future for a given scenario	Forecasting models, Markov analysis
Other models	Solve a what-if case, using a formula	Financial modeling, waiting lines

Application Case 6.2

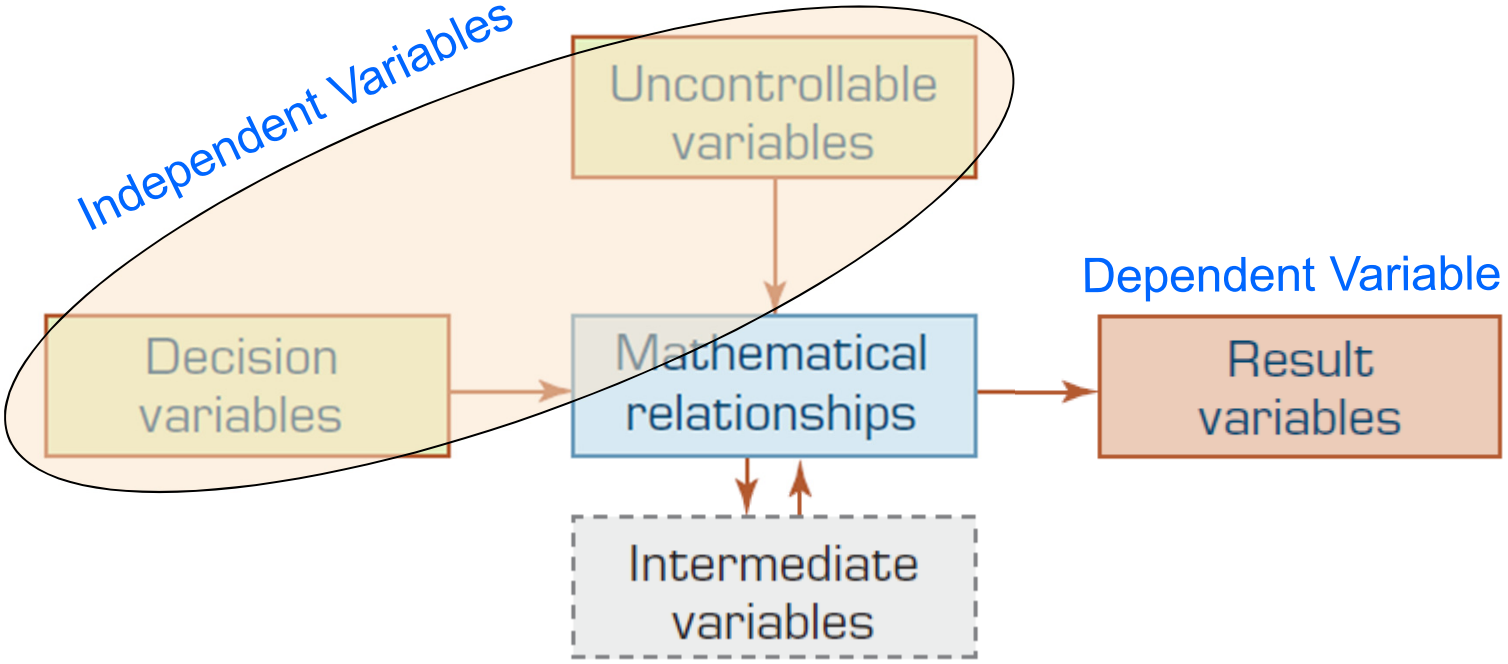
Ingram Micro Uses Business Intelligence Applications to Make Pricing Decisions

Questions for Discussion

1. What were the main challenges faced by Ingram Micro in developing a BIC?
2. List all the business intelligence solutions developed by Ingram to optimize the prices of their products and to profile their customers.
3. What benefits did Ingram receive after using the newly developed BI applications?

Structure of Mathematical Models for Decision Support

- Non-Quantitative Models (Qualitative)
- Quantitative Models: Mathematically links decision variables, uncontrollable variables, and result variables



Examples - Components of Models

TABLE 6.2 Examples of Components of Models

Area	Decision Variables	Result Variables	Uncontrollable Variables and Parameters
Financial investment	Investment alternatives and amounts	Total profit, risk Rate of return on investment (ROI) Earnings per share Liquidity level	Inflation rate Prime rate Competition
Marketing	Advertising budget Where to advertise	Market share Customer satisfaction	Customer's income Competitor's actions
Manufacturing	What and how much to produce Inventory levels Compensation programs	Total cost Quality level Employee satisfaction	Machine capacity Technology Materials prices
Accounting	Use of computers Audit schedule	Data processing cost Error rate	Computer technology Tax rates Legal requirements
Transportation	Shipments schedule Use of smart cards	Total transport cost Payment float time	Delivery distance Regulations
Services	Staffing levels	Customer satisfaction	Demand for services

The Structure of a Mathematical Model

- The components of a quantitative model are linked together by mathematical (algebraic) expressions—equations or inequalities.
- Example: Profit - $P = R - C$
  - where P = profit, R = revenue, and C = cost
- Example: Simple Present-Value formulation

$$P = \frac{F}{(1+i)^n} = \frac{100{,}000}{(1+0.1)^5} = 62{,}092$$

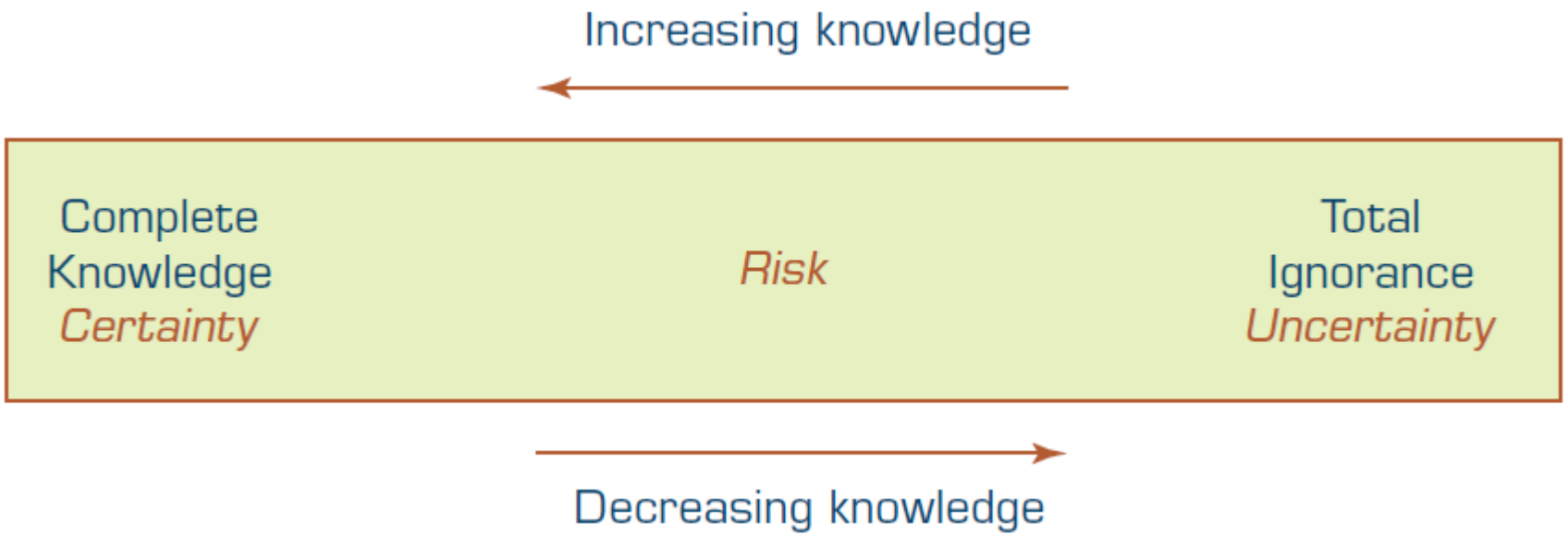
  - where P = present value, F = future cash-flow, i = interest rate, and n = number of period/years

Modeling and Decision Making - Under Certainty, Uncertainty, and Risk

- Certainty
  - Assume complete knowledge
  - All potential outcomes are known
  - May yield optimal solution
- Uncertainty
  - Several outcomes for each decision
  - Probability of each outcome is unknown
  - Knowledge would lead to less uncertainty
- Risk analysis (probabilistic decision making)
  - Probability of each of several outcomes occurring
  - Level of uncertainty → Risk (expected value)

Modeling and Decision Making - Under Certainty, Uncertainty, and Risk

- The **zones** of decision making



Application Case 6.3

American Airlines Uses Should-Cost Modeling to Assess the Uncertainty of Bids for Shipment Routes

Questions for Discussion

1. Besides reducing the risk of overpaying or underpaying suppliers, what are some other benefits AA would derive from its "should-be" model?
2. Can you think of other domains besides air transportation where such a model could be used?
3. Discuss other possible methods with which AA could have solved its bid overpayment and underpayment problem.

Decision Modeling with Spreadsheets

- Spreadsheet
  - Most popular *end-user modeling tool*
  - Flexible and easy to use
  - Powerful functions (add-in functions)
  - Programmability (via macros)
  - What-if analysis and goal seeking
  - Simple database management
  - Seamless integration of model and data
  - Incorporates both static and dynamic models
  - Examples: Microsoft Excel, Lotus 1-2-3

Application Case 6.4

Pennsylvania Adoption Exchange Uses Spreadsheet Model to Better Match Children with Families

Questions for Discussion

1. What were the challenges faced by PAE while making adoption matching decisions?
2. What features of the new spreadsheet tool helped PAE solve their issues of matching a family with a child?

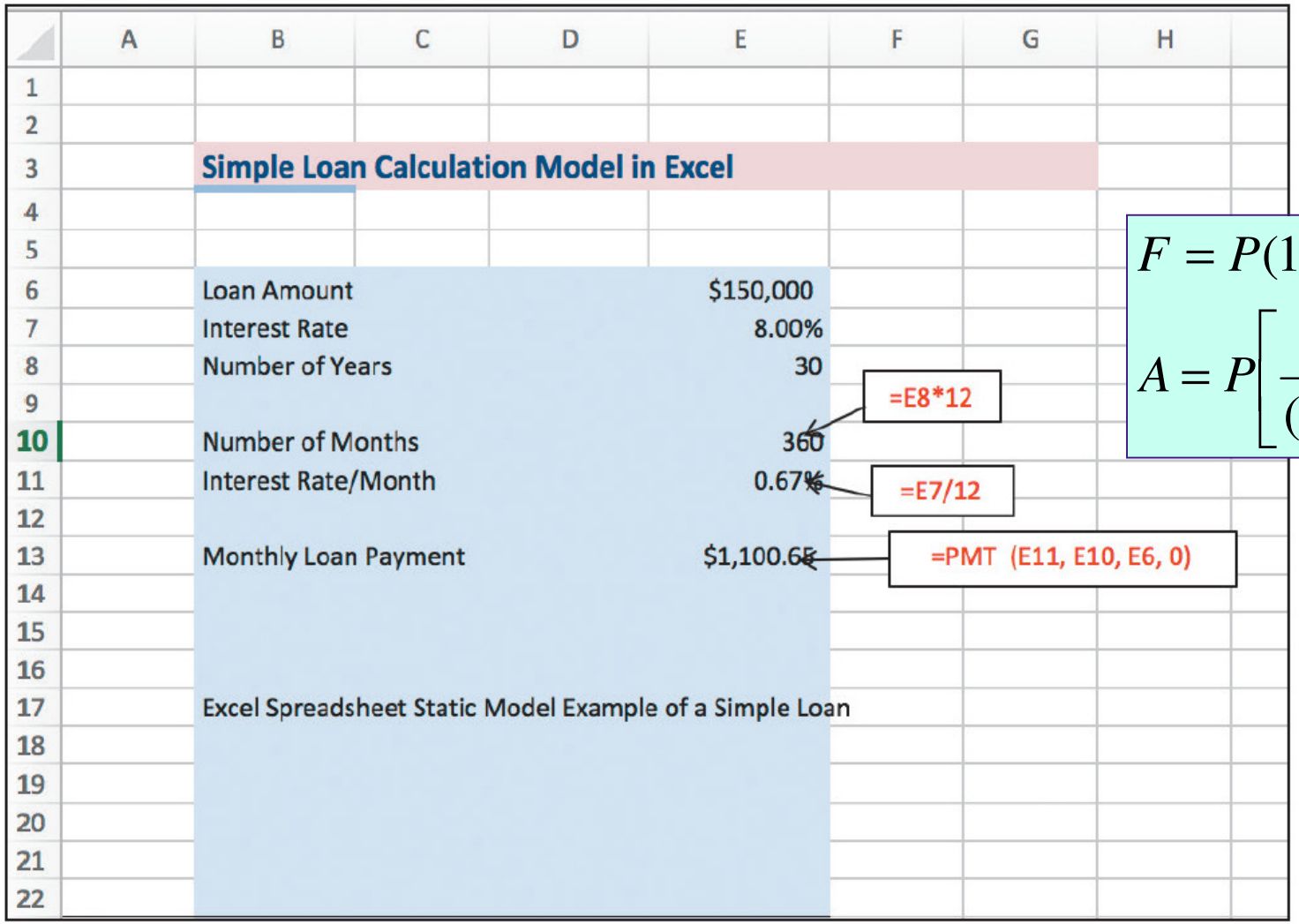
Application Case 6.5

Metro Meals on Wheels Treasure Valley Uses Excel to Find Optimal Delivery Routes

Questions for Discussion

1. What were the challenges faced by Metro Meals on Wheels Treasure Valley related to meal delivery before adoption of the spreadsheet-based tool?
2. Explain the design of the spreadsheet-based model.
3. What are the intangible benefits of using the Excel-based model to Metro Meals on Wheels?

Excel spreadsheet - Static Model Example:
(Simple loan calculation of monthly payments)



Excel spreadsheet - Dynamic Model Example:
(Simple loan calculation of monthly payments & effects of prepayment)