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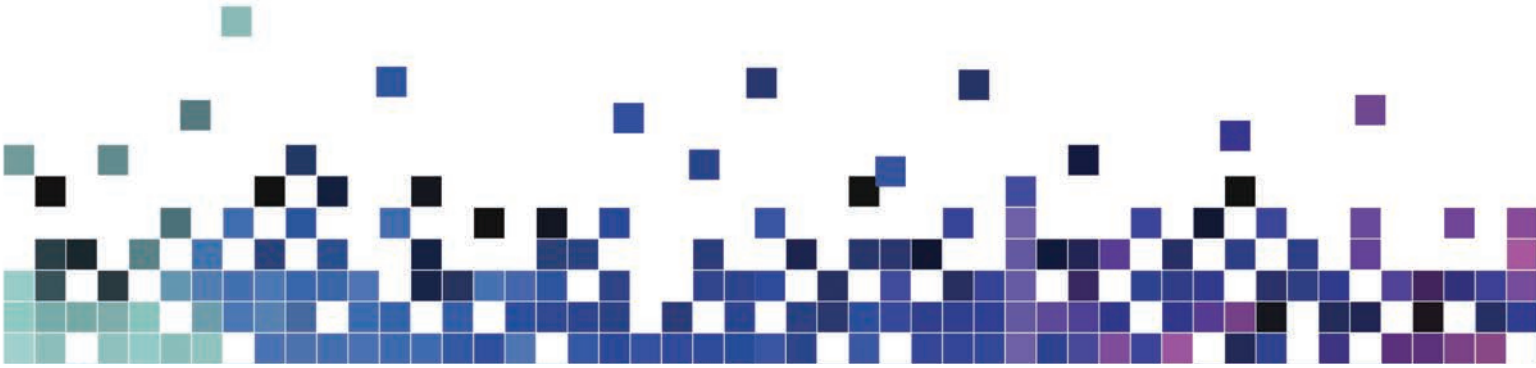

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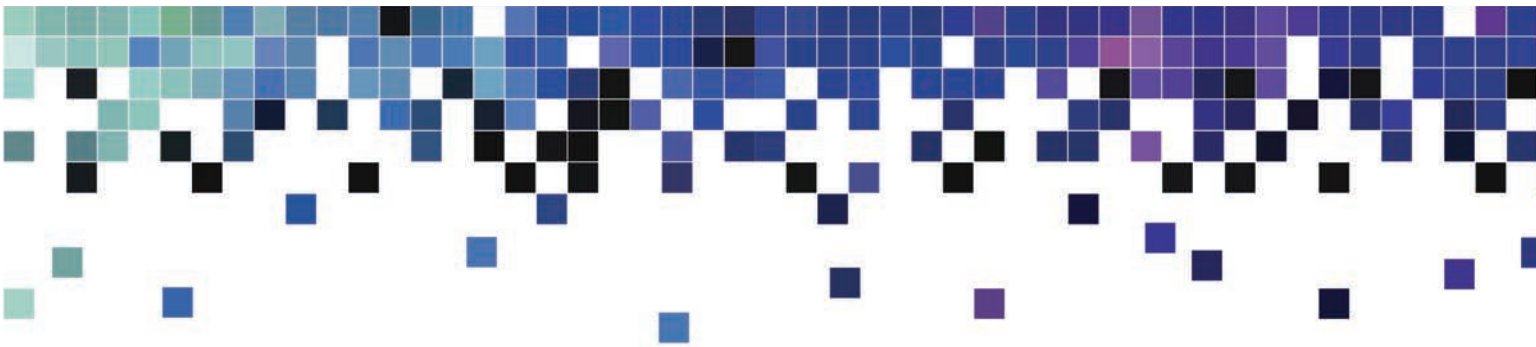

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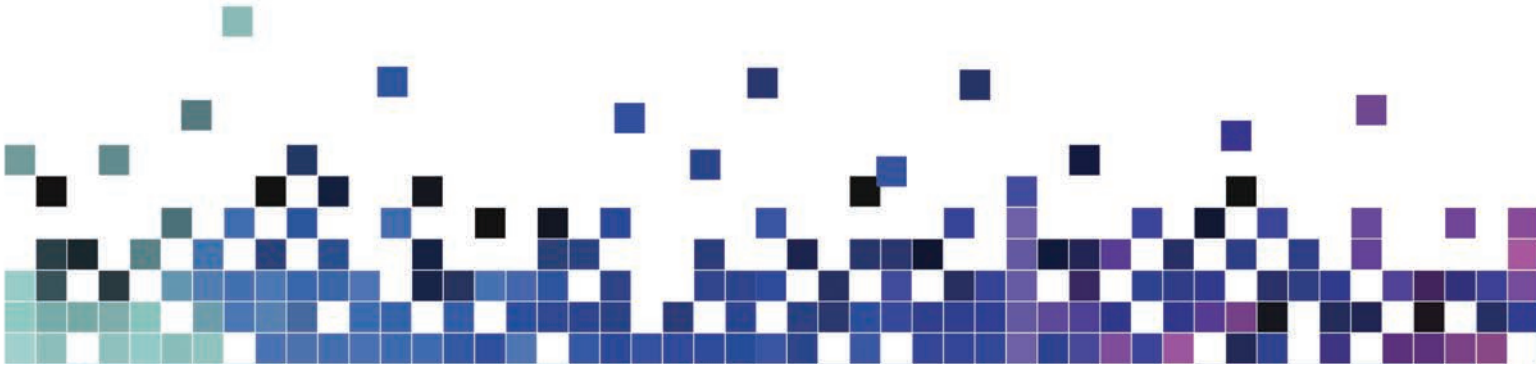

Business Analytics

Methods, Models, and Decisions

James R. Evans | University of Cincinnati

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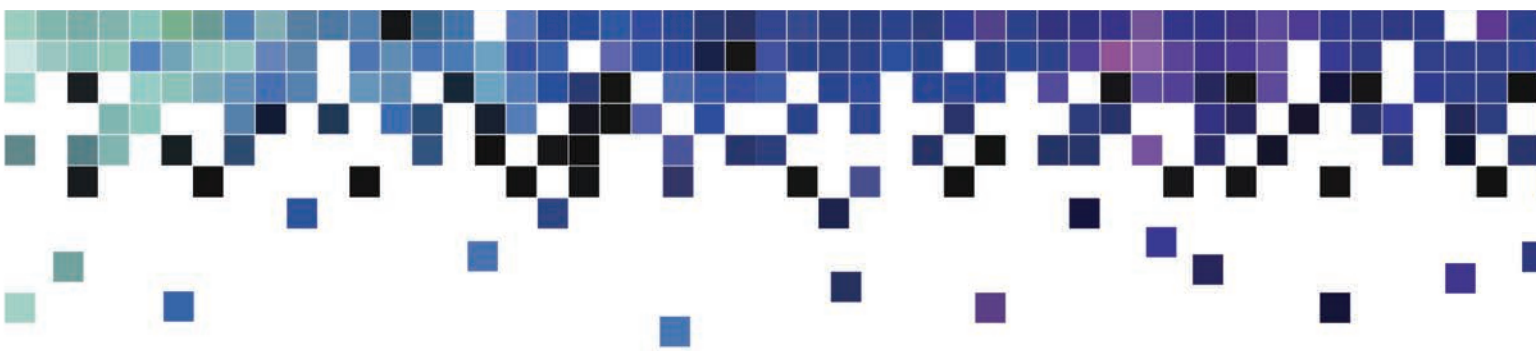

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Online Supplements: Information about how to access and use Analytic Solver Basic are available for download at www.pearsonglobaleditions.com.

Getting Started with Analytic Solver
Using Advanced Regression Techniques in Analytic Solver
Using Forecasting Techniques in Analytic Solver
Using Data Mining in Analytic Solver
Model Analysis in Analytic Solver
Using Monte Carlo Simulation in Analytic Solver
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Using Optimization Parameter Analysis in Analytic Solver
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Preface

In 2007, Thomas H. Davenport and Jeanne G. Harris wrote a groundbreaking book, *Competing on Analytics: The New Science of Winning* (Boston: Harvard Business School Press). They described how many organizations are using analytics strategically to make better decisions and improve customer and shareholder value. Over the past several years, we have seen remarkable growth in analytics among all types of organizations. The Institute for Operations Research and the Management Sciences (INFORMS) noted that analytics software as a service is predicted to grow at three times the rate of other business segments in upcoming years.[1] In addition, the *MIT Sloan Management Review* in collaboration with the IBM Institute for Business Value surveyed a global sample of nearly 3,000 executives, managers, and analysts.[2] This study concluded that top-performing organizations use analytics five times more than lower performers, that improvement of information and analytics was a top priority in these organizations, and that many organizations felt they were under significant pressure to adopt advanced information and analytics approaches. Since these reports were published, the interest in and the use of analytics has grown dramatically.

In reality, business analytics has been around for more than a half-century. Business schools have long taught many of the core topics in business analytics—statistics, data analysis, information and decision support systems, and management science. However, these topics have traditionally been presented in separate and independent courses and supported by textbooks with little topical integration. This book is uniquely designed to present the emerging discipline of business analytics in a unified fashion consistent with the contemporary definition of the field.

About the Book

This book provides undergraduate business students and introductory graduate students with the fundamental concepts and tools needed to understand the role of modern business analytics in organizations, to apply basic business analytics tools in a spreadsheet environment, and to communicate with analytics professionals to effectively use and interpret analytic models and results for making better business decisions. We take a balanced, holistic approach in viewing business analytics from descriptive, predictive, and prescriptive perspectives that define the discipline.

[1]Anne Robinson, Jack Levis, and Gary Bennett, INFORMS News: INFORMS to Officially Join Analytics Movement. http://www.informs.org/ORMS-Today/Public-Articles/October-Volume-37-Number-5/INFORMS-News-INFORMS-to-Officially-Join-Analytics-Movement.

[2]"Analytics: The New Path to Value," *MIT Sloan Management Review* Research Report, Fall 2010.

This book is organized in five parts.

1. Foundations of Business Analytics

   The first two chapters provide the basic foundations needed to understand business analytics and to manipulate data using Microsoft Excel. Chapter 1 provides an introduction to business analytics and its key concepts and terminology, and includes an appendix that reviews basic Excel skills. Chapter 2, Database Analytics, is a unique chapter that covers intermediate Excel skills, Excel template design, and PivotTables.

2. Descriptive Analytics

   Chapters 3 through 7 cover fundamental tools and methods of data analysis and statistics. These chapters focus on data visualization, descriptive statistical measures, probability distributions and data modeling, sampling and estimation, and statistical inference. We subscribe to the American Statistical Association's recommendations for teaching introductory statistics, which include emphasizing statistical literacy and developing statistical thinking, stressing conceptual understanding rather than mere knowledge of procedures, and using technology for developing conceptual understanding and analyzing data. We believe these goals can be accomplished without introducing every conceivable technique into an 800–1,000 page book as many mainstream books currently do. In fact, we cover all essential content that the state of Ohio has mandated for undergraduate business statistics across all public colleges and universities.

3. Predictive Analytics

   In this section, Chapters 8 through 12 develop approaches for applying trendlines and regression analysis, forecasting, introductory data mining techniques, building and analyzing models on spreadsheets, and simulation and risk analysis.

4. Prescriptive Analytics

   Chapters 13 and 14 explore linear, integer, and nonlinear optimization models and applications. Chapter 15, Optimization Analytics, focuses on what-if and sensitivity analysis in optimization, and visualization of Solver reports.

5. Making Decisions

   Chapter 16 focuses on philosophies, tools, and techniques of decision analysis.

Changes to the Third Edition

The third edition represents a comprehensive revision that includes many significant changes. The book now relies only on native Excel, and is independent of platforms, allowing it to be used easily by students with either PC or Mac computers. These changes provide students with enhanced Excel skills and basic understanding of fundamental concepts. *Analytic Solver* is no longer integrated directly in the book, but is illustrated in online supplements to facilitate revision as new software updates may occur. These supplements plus information regarding how to access *Analytic Solver* may be accessed at http://www.pearsonglobaleditions.com.

Key changes to this edition are as follows:

- Also available for purchase (separately) is MyLab Statistics, a teaching and learning platform that empowers you to reach every student. By combining trusted author content with digital tools and a flexible platform, MyLab personalizes the

learning experience and improves results for each student. For example, new Excel and StatCrunch Projects help students develop business decision-making skills.

- Each chapter now includes a short section called *Technology Help*, which provides useful summaries of key Excel functions and procedures, and the use of supplemental software including *StatCrunch* and *Analytic Solver Basic.*
- Chapter 1 includes an Appendix reviewing basic Excel skills, which will be used throughout the book.
- Chapter 2, Database Analytics, is a new chapter derived from the second edition that focuses on applications of Excel functions and techniques for dealing with spreadsheet data, including a new section on Excel template design.
- Chapter 3, Data Visualization, includes a new Appendix illustrating Excel tools for Windows and a brief overview of Tableau.
- Chapter 5, Probability Distributions and Data Modeling, includes a new section on Combinations and Permutations.
- Chapter 6, Sampling and Estimation, provides a discussion of using data visualization for confidence interval comparison.
- Chapter 9, Forecasting Techniques, now includes Excel approaches for double exponential smoothing and Holt-Winters models for seasonality and trend.
- Chapter 10, Introduction to Data Mining, has been completely rewritten to illustrate simple data mining techniques that can be implemented on spreadsheets using Excel.
- Chapter 11, Spreadsheet Modeling and Analysis, is now organized along the analytic classification of descriptive, predictive, and prescriptive modeling.
- Chapter 12 has been rewritten to apply Monte-Carlo simulation using only Excel, with an additional section of systems simulation concepts and approaches.
- Optimization topics have been reorganized into two chapters—Chapter 13, Linear Optimization, and Chapter 14, Integer and Nonlinear Optimization, which rely only on the Excel-supplied *Solver*.
- Chapter 15 is a new chapter called Optimization Analytics, which focuses on what-if and sensitivity analysis, and visualization of *Solver* reports; it also includes a discussion of how *Solver* handles models with bounded variables.

In addition, we have carefully checked, and revised as necessary, the text and problems for additional clarity. We use major section headings in each chapter and tie these clearly to the problems and exercises, which have been revised and updated throughout the book. At the end of each section we added several "Check Your Understanding" questions that provide a basic review of fundamental concepts to improve student learning. Finally, new Analytics in Practice features have been incorporated into several chapters.

Features of the Book

- **Chapter Section Headings**—with "Check Your Understanding" questions that provide a means to review fundamental concepts.
- **Numbered Examples**—numerous, short examples throughout all chapters illustrate concepts and techniques and help students learn to apply the techniques and understand the results.
- **"Analytics in Practice"**—at least one per chapter, this feature describes real applications in business.
- **Learning Objectives**—lists the goals the students should be able to achieve after studying the chapter.

- **Key Terms**—bolded within the text and listed at the end of each chapter, these words will assist students as they review the chapter and study for exams. Key terms and their definitions are contained in the glossary at the end of the book.
- **End-of-Chapter Problems and Exercises**—clearly tied to sections in each chapter, these help to reinforce the material covered through the chapter.
- **Integrated Cases**—allow students to think independently and apply the relevant tools at a higher level of learning.
- **Data Sets and Excel Models**—used in examples and problems and are available to students at www.pearsonglobaleditions.com.

Software Support

Technology Help sections in each chapter provide additional support to students for using Excel functions and tools, Tableau, and StatCrunch.

Online supplements provide detailed information and examples for using *Analytic Solver Basic*, which provides more powerful tools for data mining, Monte-Carlo simulation, optimization, and decision analysis. These can be used at the instructor's discretion, but are not necessary to learn the fundamental concepts that are implemented using Excel. Instructions for obtaining licenses for *Analytic Solver Basic* can be found on the book's website, http://www.pearsonglobaleditions.com.

To the Students

To get the most out of this book, you need to do much more than simply read it! Many examples describe in detail how to use and apply various Excel tools or add-ins. We highly recommend that you *work through these examples* on your computer to replicate the outputs and results shown in the text. You should also *compare mathematical formulas* with spreadsheet formulas and *work through basic numerical calculations by hand*. Only in this fashion will you learn how to use the tools and techniques effectively, gain a better understanding of the underlying concepts of business analytics, and increase your proficiency in using Microsoft Excel, which will serve you well in your future career.

Visit the companion Web site (www.pearsonglobaleditions.com) for access to the following:

- **Online Files:** Data Sets and Excel Models—files for use with the numbered examples and the end-of-chapter problems. (For easy reference, the relevant file names are italicized and clearly stated when used in examples.)
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- *Instructor's Solutions Manual*—The Instructor's Solutions Manual, updated and revised for the second edition by the author, includes Excel-based solutions for all end-of-chapter problems, exercises, and cases.
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- *Test Bank*—The TestBank is prepared by Paolo Catasti from Virginia Commonwealth University.
- **Need help?** Pearson Education's dedicated technical support team is ready to assist instructors with questions about the media supplements that accompany this text. The supplements are available to adopting instructors. Detailed descriptions are provided at the Instructor's Resource Center.

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James R. Evans
Department of Operations, Business Analytics, and Information Systems
University of Cincinnati
Cincinnati, Ohio

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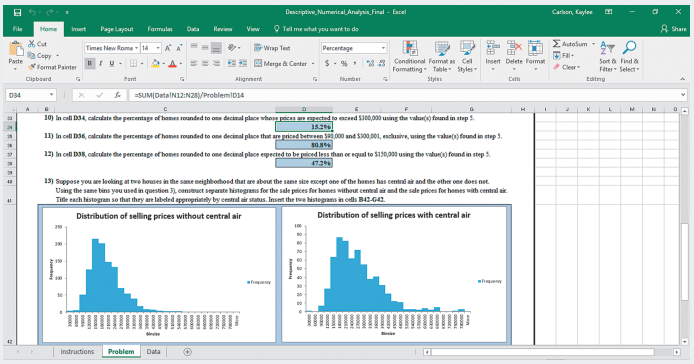

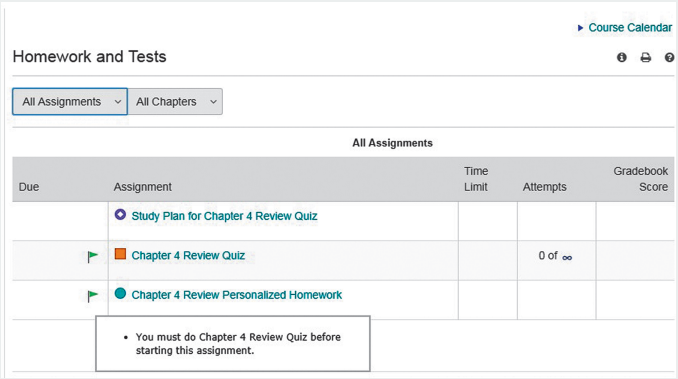

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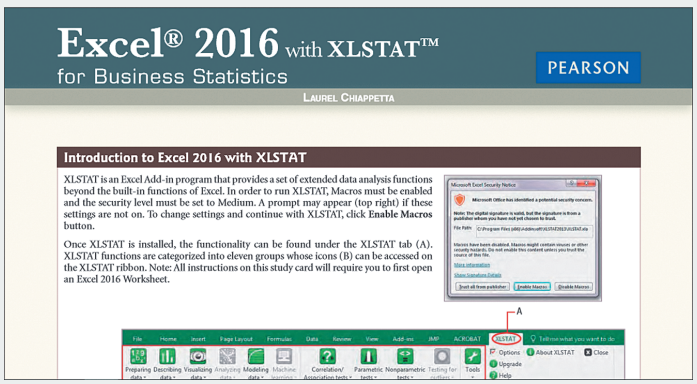

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About the Author

James R. Evans
Professor Emeritus, University of Cincinnati, Lindner College of Business

James R. Evans is Professor Emeritus in the Department of Operations, Business Analytics, and Information Systems in the College of Business at the University of Cincinnati. He holds BSIE and MSIE degrees from Purdue and a PhD in Industrial and Systems Engineering from Georgia Tech.

Dr. Evans has published numerous textbooks in a variety of business disciplines, including statistics, decision models, and analytics, simulation and risk analysis, network optimization, operations management, quality management, and creative thinking. He has published 100 papers in journals such as *Management Science, IIE Transactions, Decision Sciences, Interfaces*, the *Journal of Operations Management, the Quality Management Journal*, and many others, and wrote a series of columns in *Interfaces* on creativity in management science and operations research during the 1990s. He has also served on numerous journal editorial boards and is a past-president and Fellow of the Decision Sciences Institute. In 1996, he was an INFORMS Edelman Award Finalist as part of a project in supply chain optimization with Procter & Gamble that was credited with helping P&G save over $250,000,000 annually in their North American supply chain, and consulted on risk analysis modeling for Cincinnati 2012's Olympic Games bid proposal.

A recognized international expert on quality management, he served on the Board of Examiners and the Panel of Judges for the Malcolm Baldrige National Quality Award. Much of his research has focused on organizational performance excellence and measurement practices.

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CHAPTER

1

Introduction to Business Analytics

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LEARNING OBJECTIVES

After studying this chapter, you will be able to:

- Define business analytics.
- Explain why analytics is important in today's business environment.
- State some typical examples of business applications in which analytics would be beneficial.
- Summarize the evolution of business analytics and explain the concepts of business intelligence, operations research and management science, and decision support systems.
- Explain the difference between descriptive, predictive, and prescriptive analytics.
- State examples of how data are used in business.
- Explain the concept of a model and various ways a model can be characterized.
- Define and list the elements of a decision model.
- Illustrate examples of descriptive, predictive, and prescriptive models.
- Explain the difference between uncertainty and risk.
- Define the terms *optimization*, *objective function*, and *optimal solution*.
- Explain the difference between a deterministic and stochastic decision model.
- List and explain the steps in the problem-solving process.

The purpose of this book is to provide you with a basic introduction to the concepts, methods, and models used in business analytics so that you will develop an appreciation not only for its capabilities to support and enhance business decisions, but also for the ability to use business analytics at an elementary level in your work. In this chapter, we introduce you to the field of business analytics and set the foundation for many of the concepts and techniques that you will learn. Let's start with a rather innovative example.

Most of you have likely been to a zoo, seen the animals, had something to eat, and bought some souvenirs. You probably wouldn't think that managing a zoo is very difficult; after all, it's just feeding and taking care of the animals, right? A zoo might be the last place that you would expect to find business analytics being used, but not anymore. The Cincinnati Zoo & Botanical Garden has been an "early adopter" and one of the first organizations of its kind to exploit business analytics.[1]

Despite generating more than two-thirds of its budget through its own fundraising efforts, the zoo wanted to reduce its reliance on local tax subsidies even further by increasing visitor attendance and revenues from secondary sources such as membership, food, and retail outlets. The zoo's senior management surmised that the best way to realize more value from each visit was to offer visitors a truly transformed customer experience. By using business analytics to gain greater insight into visitors' behavior and tailoring operations to their preferences, the zoo expected to increase attendance, boost membership, and maximize sales.

The project team—which consisted of consultants from IBM and Brightstar Partners, as well as senior executives from the zoo—began translating the organization's goals into technical solutions. The zoo worked to create a business analytics platform that was capable of delivering the desired goals by combining data from ticketing and point-of-sale systems throughout the zoo with membership information and geographical data gathered from the ZIP codes of all visitors. This enabled the creation of reports and dashboards that gave everyone from senior managers to zoo staff access to real-time information that helped them optimize operational management and transform the customer experience.

By integrating weather forecast data, the zoo is now able to compare current forecasts with historic attendance and sales data, supporting better decision making for labor scheduling and inventory planning. Another area where the solution delivers new insight is food service. By opening food outlets at specific times of day when demand is highest (for example, keeping ice cream kiosks open in the

[1]IBM Software Business Analtyics, "Cincinnati Zoo transforms customer experience and boosts profits," © IBM Corporation 2012.