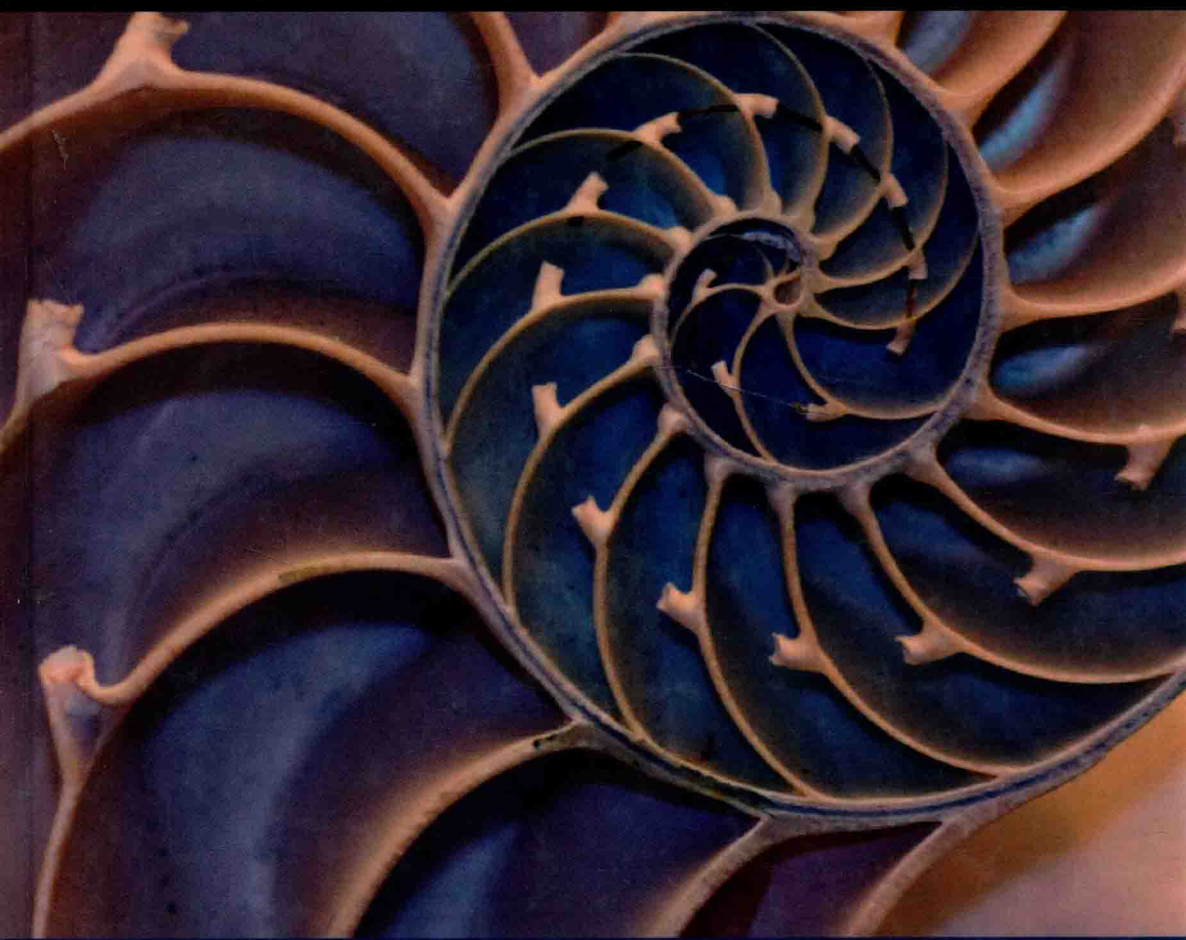
DATA MINING FOR BUSINESS ANALYTICS

CONCEPTS, TECHNIQUES, AND APPLICATIONS WITH JMP PRO®



Galit Shmueli • Peter C. Bruce • Mia L. Stephens • Nitin R. Patel

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Concepts, Techniques, and Applications with JMP Pro®

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DATA MINING FOR BUSINESS ANALYTICS

To our families

Boaz and Noa
Liz, Lisa, and Allison
Michael, Madi, Olivia, and in memory of E.C. Jr.
Tehmi, Arjun, and in memory of Aneesh

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FOREWORD

No matter what your chosen profession or place of work, your future will almost certainly be saturated with data. The modern world is defined by the bits of data pulsing from billions of keyboards and trillions of card swipes—emanating from every manner of electronic device and system—transmitted instantaneously around the globe. The sheer amount of data is measured in volumes difficult to comprehend. But it's not about how much data you have; it's what you do with it, and how quickly, that counts most. Grappling with this messy world of data and putting it to good use will be key to productive and well-functioning organizations and successful managerial careers, not just in the obvious places circling Silicon Valley such as Google and Facebook but in insurance companies, banks, auto manufacturers, airlines, hospitals, and indeed nearly everywhere.

That's where *Data Mining for Business Analytics: Concepts, Techniques and Applications with JMP Pro®* can help. Professor Shmueli and her coauthors provide a very useful guide for students of business to learn the important concepts and methods for navigating complex datasets. Born out of the authors' years of experience teaching the subject, the book has evolved from earlier editions to keep pace with the changing landscape of business analytics in graduate and undergraduate education. Most important, new with this edition is the integration of JMP Pro®, a statistical tool from SAS Institute, which is provided as the vehicle for working with data in problem sets. Learning analytics is ultimately about doing things to and with data to generate insights. Mastering one's dexterity with powerful statistical tools is a necessary and critical step in the learning process.

If you've set your sights on leading in a digital world, this book is a great place to start preparing yourself for the future.

Michael Rappa
Institute for Advanced Analytics
North Carolina State University

PREFACE

The textbook *Data Mining for Business Intelligence* first appeared in early 2007. Since then, it has been used by numerous practitioners and in many courses, ranging from dedicated data mining classes to more general business analytics courses (including our own experience teaching this material both online and in person for more than 10 years). Following feedback from instructors teaching MBA, undergraduate, and executive courses, and from students, the second edition saw revisions to some of the existing chapters and included two new topics: data visualization and time series forecasting.

This book is the first edition to fully integrate JMP Pro®[1] rather than the Microsoft Office Excel add-in, XLMiner. JMP Pro® is a desktop statistical package from SAS Institute that runs natively on Mac and Windows machines. All examples, special topics boxes, instructions, and exercises presented in this book are based on JMP 12 Pro, the professional version of JMP, which has a rich array of built- in tools for interactive data visualization, analysis, and modeling.[2]

There are other important changes in this edition. The first noticeable change is the title: other than the addition of JMP Pro®, we now use *Business Analytics* in place of *Business Intelligence*. This update reflects the change in terminology since the second edition: BI today refers mainly to reporting and data visualization (what is happening now), while BA has taken over the advanced analytics, which include predictive analytics and data mining. In this new edition we therefore also updated these terms in the book, using them as is currently common.

We added a new chapter, *Combining Methods: Ensembles and Uplift Modeling* (Chapter 13). This chapter, which is the last in Part IV on Prediction and Classification Methods, introduces two important approaches. The first—ensembles—is the combination of multiple models for improving predictive power. Ensembles have routinely proved their

[1] JMP Pro®, Version 12. SAS Institute Inc., Cary, NC 27513. See Chapter 1 for information on how to get JMP Pro®.

[2] Relevant new features in JMP Pro 13 are noted in the chapters.

usefulness in practical applications and in data mining contests. The second topic—uplift modeling—introduces an improved approach for measuring the impact of an intervention or treatment. Similar to other chapters, this new chapter includes real-world examples and end-of-chapter problems.

Other changes include the addition of two new cases based on real data (one on political persuasion and uplift modeling, and another on taxi cancellations), and the removal of one chapter, Association Rules (association rules is a feature not available in JMP 12 Pro, but will be a new feature in JMP 13 Pro).

Since the second edition's appearance, the landscape of courses using the textbook has greatly expanded: whereas initially the book was used mainly in semester-long elective MBA-level courses, it is now used in a variety of courses in Business Analytics degree and certificate programs, ranging from undergraduate programs, to post-graduate and executive education programs. Courses in such programs also vary in their duration and coverage. In many cases, our book is used across multiple courses. The book is designed to continue supporting the general Predictive Analytics or Data Mining course as well as supporting a set of courses in dedicated business analytics programs.

A general "Business Analytics," "Predictive Analytics," or Data Mining course, common in MBA and undergraduate programs as a one-semester elective, would cover Parts I–III, and choose a subset of methods from Parts IV and V. Instructors can choose to use cases as team assignments, class discussions, or projects. For a two-semester course, Part VI might be considered. For a set of courses in a dedicated Business Analytics program, here are a few courses that have been using the second edition of *Data Mining for Business Intelligence*:

Predictive Analytics: Supervised Learning In a dedicated Business Analytics program, the topic of Predictive Analytics is typically instructed across a set of courses. The first course would cover Parts I–IV and instructors typically choose a subset of methods from Part IV according to the course length. We recommend including the new Chapter 13 in such a course.

Predictive Analytics: Unsupervised Learning This course introduces data exploration and visualization, dimension reduction, mining relationships, and clustering (Parts III and V). If this course follows the Predictive Analytics: Supervised Learning course, then it is useful to examine examples and approaches that integrate unsupervised and supervised learning.

Forecasting Analytics A dedicated course on time series forecasting would rely on Part VI.

In all courses, we strongly recommend including a project component, where data are either collected by students according to their interest or provided by the instructor (e.g., from the many data mining competition datasets available). From our experience and the experience of other instructors, such projects enhance learning and provide students with an excellent opportunity to understand the strengths of data mining and the challenges that arise in working with data and solving real business problems.

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The authors thank the many people who assisted us in improving the first edition and improving it further in the second edition, and now in this JMP edition. Anthony Babinec, who has been using drafts of this book for years in his Data Mining courses at Statistics.com, provided us with detailed and expert corrections. The Statistics.com team has also provided valuable checking, trouble-shooting, and critiquing: Kuber Deokar, Instructional Operations Supervisor, and Shweta Jadhav and Dhanashree Vishwasrao, Assistant Teachers. We also thank the many students who have used and commented on earlier editions of this text at Statistics.com.

Similarly, Dan Toy and John Elder IV greeted our project with enthusiasm and provided detailed and useful comments on earlier drafts. Boaz Shmueli and Raquelle Azran gave detailed editorial comments and suggestions on the first two editions; Noa Shmueli provided edits on the new edition; Bruce McCullough and Adam Hughes did the same for the first edition. Ravi Bapna, who used an early draft in a Data Mining course at the Indian School of Business, provided invaluable comments and helpful suggestions. Useful comments and feedback have also come from the many instructors, too numerous to mention, who have used the book in their classes.

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This book would not have seen the light of day without the nurturing support of the faculty at the Sloan School of Management at MIT. Our special thanks to Dimitris Bertsimas, James Orlin, Robert Freund, Roy Welsch, Gordon Kaufmann, and Gabriel Bitran. As teaching assistants for the data mining course at Sloan, Adam Mersereau gave detailed comments on the notes and cases that were the genesis of this book, Romy Shioda helped with the

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