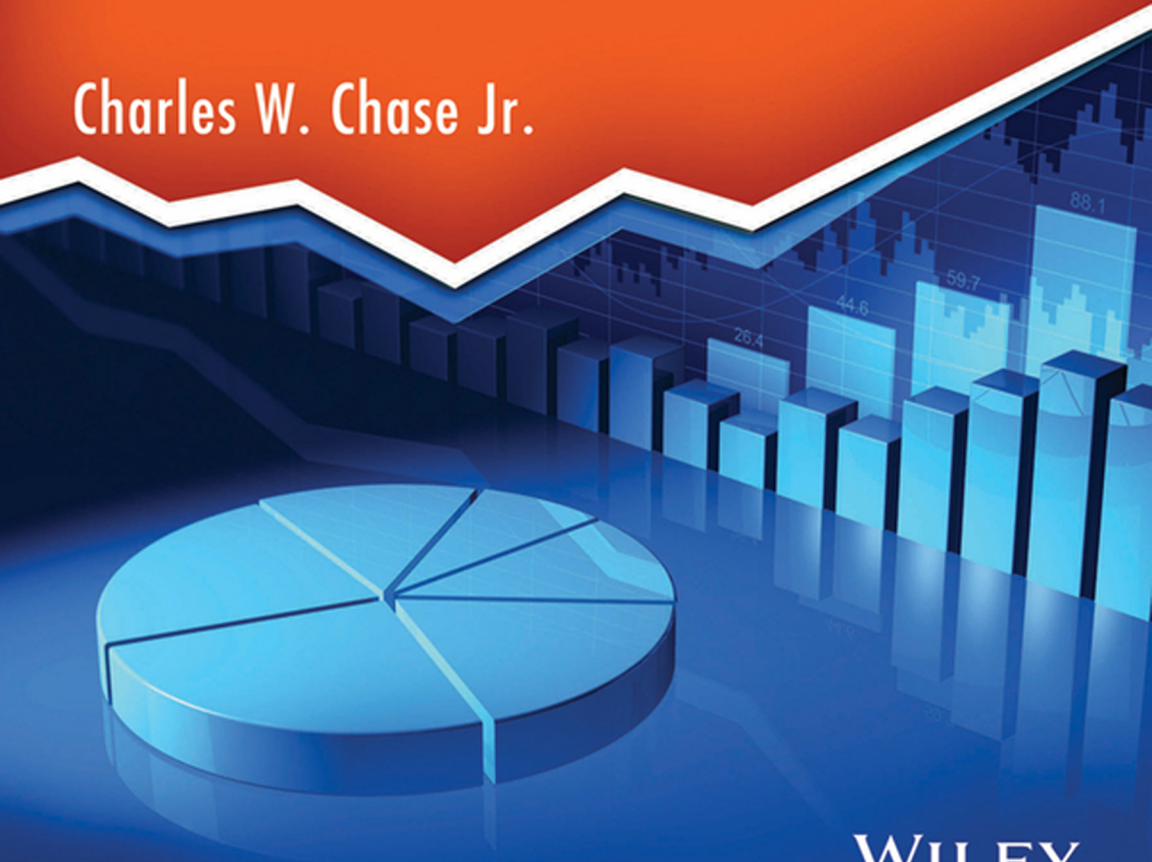
2nd Edition

DEMAND-DRIVEN FORECASTING

A Structured Approach to Forecasting

Charles W. Chase Jr.



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Foreword

Demand-Driven Forecasting was a long-overdue practical book on business forecasting when it was first published in 2009. One of the industry's top business forecasters, Charles W. Chase (also known as Charlie in the industry) has done a remarkable job in revising this second edition. I have been involved in business forecasting—the demand forecasting that is done by industry forecasters—for over 30 years and have not seen a better reference book for them. The content Charlie has added has made the revision much more relevant and useful. This is especially true as companies are doing more demand shaping during the turbulent economic times since the Great Recession. All businesses are keen to understand what is driving their volatile demand as well as to leverage demand shaping to compete and thrive in tough economic climates.

A JOURNEY DOWN MEMORY LANE

Business forecasting during my early years was largely based on the exponential smoothing forecasting methods developed by industry practitioner Robert G. (Bob) Brown, who published several books starting in the late 1950s. These exponential smoothing methods live on today and are often the under-the-hood statistical forecasting engines powering many software packages. Forecasting methods have evolved since that time to include a wide variety of statistical time series methods, many of which were discussed in several revisions of forecasting books written by two leading academic forecasters, Spyros Makridakis and Steven C. Wheelwright, starting in the late 1970s.

During the first half of my career, advanced methods focused on what might be termed history-driven forecasting, because the methods involved analyzing years of historical data in order to identify recurring patterns from which to project the future. Midway in my career, the focus started changing toward demand-driven forecasting.

The last several decades or so have been a period of increased consumerism, especially in the United States. During this time marketing and sales organizations developed more sophisticated and effective demand-shaping techniques to simulate demand for the products they were promoting. Industry forecasters, by necessity, started to experiment with and utilize methods that no longer assumed that demand just magically happened and could be estimated only from understanding what happened in the past. They started leveraging cause-and-effect methods, such as multiple regression methods, and time series methods incorporating causal factors, such as autoregressive integrated moving average (ARIMA) models with explanatory variables in order to reflect the fact that promotional activities would shape and create demand and therefore needed to be understood and incorporated into a forecast. (To reflect their importance, this second edition places increased emphasis on regression and ARIMA methods.)

Coincidently, midway in my career I was fortunate enough to meet Charlie Chase, who was already a pioneer in demand-driven forecasting. I was researching ways to do promotional forecasting for a consulting engagement that I was working on for a large drugstore chain. Professionally it was a watershed event for me, as my advocacy moved from largely espousing history-driven forecasting to including advanced demand-driven forecasting.

I had heard that Charlie had successfully implemented multivariate statistical methods to incorporate the effects of promotions at Polaroid, where he was employed at the time. Our consulting team visited him and learned a lot about how to use these sophisticated methods (which we all learned about in a college classroom) in a real-world setting. From that day on our relationship has blossomed, and we have become close colleagues and friends. We have shared a variety of ideas over time, such as multi-tiered forecasting concepts. Charlie introduced me to the Institute of Business Forecasting & Planning (IBF), an organization whose mission he was helping to recast at the time. From those efforts, the IBF has successfully evolved into the preeminent organization for "practical" business forecasters and planners.

QUALIFIED TO DEFINE DEMAND-DRIVEN FORECASTING

Charlie Chase is one of the top thought leaders in the business forecasting community, which makes him eminently qualified to write (what I consider to be) the definitive book on demand-driven forecasting. He bears many scars from the battles it took to get this type of forecasting implemented at a variety of consumer products companies, where the shaping of demand is critical to long-term market success. At these companies, running promotional and advertising campaigns, continually altering prices, and launching new products is a way of life. Thus, not only has Charlie had to leverage the forecasting methods learned in the classroom, but he has also had to develop innovative yet practical methods while in the heat of the battle at these dynamic companies.

This is why I believed the demand-driven concepts discussed in the original book were immediately applicable to business forecasters working in product industries as well as to those working at service-oriented and public sector organizations. In the original book, however, new product forecasting (a key element of demand shaping) was covered in a cursory fashion. This second edition has a completely new chapter on this topic and gives new product forecasting the appropriate due that it deserves.

With the rise in consumerism during the past 20 years or so, a business forecaster's job has become much more difficult. The dramatic growth in the entities that need to be forecast by multinational organizations has made demand forecasting methods and systems larger in scale. Business planning has become more complex in terms of having to deal with the myriad of products being sold—many with short life cycles (e.g., proliferation of stock-keeping units)—as well as the number of countries into which they are sold and the number of channels they are sold through. Technology has been evolving to keep up with this dramatic growth in scale, and Charlie has played an influential role in this area as well. His discussion of forecasting technology in this book comes from a wealth of experience in helping to develop and implement sophisticated forecasting systems enabled by leading-edge technology.

PRIMER ON ADVANCED FORECASTING

When I first reviewed a draft of the original book, my initial reaction was that it represented a primer on advanced forecasting. My second reaction was: Is that statement an oxymoron? It isn't, because *Demand-Driven Forecasting* takes the reader on a journey from the basic methods espoused by forecasting pioneer Bob Brown over 50 years ago to some of the most innovative business forecasting methods in use today.

After clearly defining demand-driven forecasting, the original and this second edition take the reader from a review of the most basic forecasting methods, to the most advanced time series methods, and then on to the most innovative techniques in use today, such as the linking of supply and demand to support multi-tiered forecasting and the incorporation of downstream demand signals. As Bob Brown's books turbocharged the evolution of history-driven forecasting, Charlie's books do the same for demand-driven forecasting. To the readers of this edition: Enjoy reading it and be prepared to become even more demand driven.

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Preface

The global marketplace continues to be volatile, fragmented, and dynamic. Supply processes continue to mature faster than demand. As a result, there is a larger gap to fill in the redefinition of demand forecasting processes to become demand driven than in any other area of the supply chain. This redefinition of demand forecasting will require new data (downstream point-of-sales [POS] data), processes, analytics, and enabling technologies. To become demand driven, companies need to identify the right market signals, build demand-sensing capabilities, define demand-shaping processes, and effectively translate demand signals to create a more effective response.

The second edition of the book focuses on the continued evolution of demand-driven forecasting and addresses the challenges companies are experiencing with demand. Those challenges are making it more difficult to get demand right than to get supply right. Talent continues to be scarce, making it difficult to invest in enabling technologies to support the evolving demand forecasting process. Organizationally, the work on demand forecasting processes is fraught with political issues. This makes it more politically charged than supply processes. As a result, many companies often want to throw in the towel. They want to forget about demand and focus only on the redesign of supply processes to become more reliable, resilient, and agile. The list of possible projects is long and often includes lean manufacturing, cycle time reduction, order management, and the redefinition of distribution center flows. However, focusing only on supply has shown limited results.

Supply-centric approaches to resolving demand challenges can increase the complexity. They cannot improve the potential of the supply chain as a complex system. Working supply processes in isolation from demand only drives up costs, increases working capital, and reduces asset utilization. The secret to building demand excellence is to build the right stuff in the demand management processes. Improvements in demand forecasting have proven to enhance the supply chain

by providing the right foundation to make effective trade-offs against the supply chain.

The development of a demand forecasting strategy is easier said than done. Demand management systems were designed for the supply chains of the 1990s, when there was less complexity. Over the past decade, supply chains have become more complex because of consolidation through acquisition and globalization. Unfortunately, the evolution of demand forecasting practices has not kept pace with business needs.

Historic approaches to demand forecasting emphasized planning rather than analytics, making it difficult to meet the task of creating a more accurate demand response. As a result, companies are coming to realize that the demand forecasting process requires a complete reengineering with an outward-in orientation supported by data and analytics. The process needs to focus on identifying market opportunities (market signals) and leveraging internal sales and marketing programs to influence customers to purchase the company's products and services. It requires a champion—an organizational leader—to orchestrate the change management requirements of the demand-driven process. This gap in demand forecasting will be the area of highest priority for supply chain leaders in the coming years.

The preparation of this second edition, like the first, is based on the author's view that the book should do six things:

1. Cover the full range of challenges regarding becoming demand driven, including process, statistical methods, performance metrics, and enabling technology.
2. Provide a complete description of the essential characteristics of demand-driven process.
3. Present the steps needed for the practical application of statistical methods.
4. Provide a practical framework rather than focusing on the unnecessary theoretical details that are not essential to understanding how to apply the methods.
5. Provide a step-by-step structured approach to applying the various statistical methods, demonstrating their advantages and disadvantages, so the reader can choose the most appropriate method for each forecasting situation.

6. Cover the most comprehensive set of statistical forecasting methods and approaches to demand forecasting.

NEW IN THIS EDITION

While meeting these criteria, this second edition includes major revisions for Chapters 1, 2, 5, 6, and 8 plus three completely new chapters. The purpose has not been merely to revise this edition but to rewrite it to include the latest theoretical developments and practical challenges while presenting the most recent empirical findings, thinking, and enabling technology advancements. Some of the new material covered includes:

- New case studies and examples.
- A completely new Chapter 2 on demand-driven forecasting outlining new definitions and the addition of demand shifting.
- Additional definitions and examples illustrating the application of additive and multiplicative winters' methods.
- An expanded regression chapter.
- A completely new and expanded autoregressive integrated moving average (ARIMA) chapter covering nonseasonal and seasonal ARIMA models, transfer functions, and cross-correlation function plots.
- A revised weighted combined modeling chapter.
- A completely new Chapter 10 on new product forecasting using structured judgment.

UNIQUE FEATURES

The book is distinctive for its attention to practical demand forecasting challenges and its comprehensive coverage of both statistical methods and how to apply those statistical methods in practice within a demand-driven forecasting process using real data and examples. In particular:

- There are many real data examples and a number of examples based on the author's experience. All the data sets in the book are from actual events but have been masked to protect confidentiality.

- There is emphasis on using graphical methods and plots to understand the analysis and statistical output.
- The author's perspective is that demand forecasting is much more than just fitting models to historical demand data. Although explaining and understanding the past history of demand is important, it is not adequate for accurately predicting future demand.
- Combining data, analytics, and domain knowledge is the only formula for successful demand forecasting.
- The second edition includes the most recent developments in demand-driven forecasting and implementation.

Acknowledgments

A number of friends and colleagues, influential to my career, have reviewed both editions of the manuscript and provided constructive recommendations. The continued support from my manager, Mark Demers, SAS Institute Inc., encouraged me to rewrite the book.

I also want to thank Stacey Hamilton, my SAS editor; Mike Gilliland, SAS Institute Inc.; and Dr. Aric Labarr at North Carolina State University for their help with the editing of this manuscript. Their input and suggestions have enhanced the quality of the book. Finally, I thank my wife, Cheryl, *again* for keeping the faith all these years and supporting my career. Without her support and encouragement, I would not have been in a position to write this book.

Charles W. Chase Jr.
Chief Industry Consultant & Subject Matter Expert
SAS Institute, Inc.

About the Author

Charles Chase is Chief Industry Consultant in the Manufacturing and Supply Chain Global Practice at SAS. He is the primary architect and strategist for delivering demand planning and forecasting solutions to improve supply chain efficiencies for SAS customers. He has more than 26 years of experience in the consumer packaged goods industry and is an expert in sales forecasting, market response modeling, econometrics, and supply chain management. Prior to working at SAS, Chase led the strategic marketing activities in support of the launch of SAS Forecast Server, which won the "Trend-Setting Product of the Year" award for 2005 by *KM World* magazine, and SAS Demand-Driven Forecasting. He has also been involved in the reengineering, design, and implementation of three forecasting and marketing intelligence processes/systems. Chase has also worked at the Mennen Company, Johnson & Johnson, Consumer Products Inc., Reckitt Benckiser, the Polaroid Corporation, Coca-Cola, Wyeth-Ayerst Pharmaceuticals, and Heineken USA.

Chase is former associate editor of the *Journal of Business Forecasting* and is currently an active member of the Practitioner Advisory Board for *Foresight: The International Journal of Applied Forecasting*. He has authored several articles on sales forecasting and market response modeling. He was named "2004 Pro to Know" in the February/March 2004 issue of *Supply and Demand Chain Executive Magazine*. He is also the coauthor of *Bricks Matter: The Role of Supply Chains in Building Market-Driven Differentiation* (Wiley, 2012).

CHAPTER 1

Demystifying Forecasting: Myths versus Reality

It has been an exciting time for the field of demand forecasting. All the elements are in place to support demand forecasting from a fact-based perspective. Advanced analytics has been around for well over 100 years and data collection has improved significantly over the past decade, and finally data storage and processing capabilities have caught up. It is not uncommon for companies' data warehouses to capture and store terabits of information on a daily basis, and parallel processing and grid processing have become common practices. With improvements in data storage and processing over the past decade, demand forecasting is now poised to take center stage to drive real value within the supply chain.

What's more, predictive analytics has been gaining wide acceptance globally across all industries. Companies are now leveraging predictive analytics to uncover patterns in consumer behavior, measure

the effectiveness of their marketing investment strategies, and optimize financial performance. Using advanced analytics, companies can now sense demand signals associated with consumer behavior patterns and shape future demand using predictive analytics and data mining technology. They can also measure how effective their marketing campaigns are in driving consumer demand for their products and services, and therefore they can optimize their marketing spending across their product portfolios. As a result, a new buzz phrase has emerged within the demand forecasting discipline: *sensing, shaping, and responding to demand*, or what is now being called demand-driven forecasting.

With all these improvements, there has been a renewed focus on demand forecasting as the key driver of the supply chain. As a result, demand forecasting methods and applications have been changing, emphasizing predictive analytics using what-if simulations and scenario planning to shape and proactively drive, rather than react to, demand. The widespread acceptance of these new methods and applications is being driven by pressures to synchronize demand and supply to gain more insights into why consumers buy manufacturers' products. The wide swings in replenishment of demand based on internal shipments to warehouses and the corresponding effects on supply can no longer be ignored or managed effectively without great stress on the upstream planning functions within the supply chain.

New enabling technologies combined with data storage capabilities have now made it easier to store causal factors that influence demand in corporate enterprise data warehouses; factors may include price, advertising, in-store merchandising (e.g., displays, features, features/displays, temporary price increases), sales promotions, external events, competitor activities, and others, and then use advanced analytics to proactively shape future demand utilizing what-if analysis or simulations based on the parameters of the models to test different marketing strategies. The focus on advanced analytics is driven primarily by the need of senior management to gain more insights into the business while growing unit volume and profit with fewer marketing dollars. Those companies that are shaping future demand using what-if analysis are experiencing additional efficiencies downstream in the supply chain. For example, senior managers are now able to measure the effects of a 5 percent price increase with a good degree of accuracy

and ask additional questions, such as: What if we increase advertising by 10 percent and add another sales promotion in the month of June? How will that affect demand both from a unit volume and profit perspective? Answers to such questions are now available in real time for nonstatistical users employing advanced analytics with user-friendly point-and-click interfaces. The heavy-lifting algorithms are embedded behind the scenes, requiring quarterly or semiannual recalibration by statisticians who are either on staff or hired through outside service providers.

The results of these what-if simulations are used to enhance or shape future demand forecasts by validating or invalidating assumptions using domain knowledge, analytics, and downstream data from sales and marketing rather than gut-feeling judgment.

With all the new enhancements, there are still challenges ahead for demand forecasting. Many organizations struggle with how to analyze and make practical use of the mass of data being collected and stored. Others are still struggling to understand how to synchronize and share external information with internal data across their technology architectures. Nevertheless, they are all looking for enterprise-wide solutions that provide actionable insights to make better decisions that improve corporate performance through improved intelligence.

Improvements in demand forecasting accuracy have been a key ingredient in allowing companies to gain exponential performance in supply chain efficiencies. Unfortunately, demand forecasting still suffers from misconceptions that have plagued the discipline for decades and have become entrenched in many corporate cultures. The core misconception that has troubled companies for years is that simple forecasting methods, such as exponential smoothing, which measure the effects of trend, seasonality, and randomness (or what is known as unexplained randomness, or noise), can be used to create statistical baseline forecasts and enhanced (or improved) by adding gut-feeling judgmental overrides. Those overrides usually are based on inflated assumptions reflecting personal bias. The second misconception is that these judgmental overrides can be managed at aggregated levels (higher levels in the product hierarchy) without paying attention to the lower-level mix of products that make up the aggregate. The aggregation is required to manage the large scale of data that usually

span multiple geographic regions, markets, channels, brands, product groups, and products (stock-keeping units [SKUs]). The sheer size of the data makes it difficult to manage the overrides at the lowest level of granularity. Companies compromise; they make judgmental overrides at higher aggregate levels and disaggregate it down using Excel spreadsheets and very simplistic, static averaging techniques. In other words, the averages are constant into the future and do not account for seasonality and trends at the lower levels. In many cases, products within the same product group are trending in different directions.

Another misconception is political bias based on the needs of the person or purpose of the department making the judgmental overrides. For example, depending on the situation, some sales departments will lower the forecast to reduce their sales quota in order to ensure that they make bonus. This is known as sandbagging. Other sales departments that have experienced lost sales due to back orders (not having the inventory available in the right place and the right time) will raise the forecast in the hopes of managing inventory levels via the sales department forecast. This method creates excess inventory as the operations planning department is also raising safety stocks to cover the increase in the sales department forecast. The problem is compounded, creating excess finished goods inventory, not to mention increased inventory carrying costs. The finance department always tries to hold to the original budget or financial plan, particularly when sales are declining. Finally, the marketing department almost always raises its forecast in anticipation of the deployment of all the marketing activities driving incremental sales. The marketing department also receives additional marketing investment dollars if it shows that its brands and products are growing. So marketing tends to be overly optimistic with marketing forecasts, particularly when they raise the forecast to reflect sales promotions and/or marketing events.

These misconceptions are difficult to overcome without a great deal of change management led by a corporate "champion." A corporate champion is usually a senior-level manager (e.g., director, vice president, or higher) who has the authority to influence change within the company.

This person usually has the ear of the chief executive officer, chief financial officer, or chief marketing officer and is also regarded within

the organization as a domain knowledge expert in demand forecasting with a broad knowledge base that spans multiple disciplines. He or she usually has some practical knowledge of and experience in statistical forecasting methods and a strong understanding of how demand forecasting affects all facets of the company.

The purpose of this book is to put to rest many of the misconceptions and bad habits that have plagued the demand forecasting discipline. Also, it provides readers with a structured alternative that combines data, analytics, and domain knowledge to improve the overall performance of the demand forecasting process of a company.

DATA COLLECTION, STORAGE, AND PROCESSING REALITY

Over the past ten years, we have seen a great improvement in data storage. For example, companies that only a few years ago were struggling with 1 terabyte of data are now managing in excess of 68 terabytes of data with hundreds of thousands of SKUs. In fact, you can purchase an external hard drive that fits in your pocket for your personal computer (PC) or laptop that can store 1 terabyte of data for less than $150. Data storage costs have gone down substantially, making it easier to justify the collection of additional data in a more granular format that reflects complex supply chain networks of companies.

Most companies review their forecasts in a product hierarchy that mirrors the way they manage their supply chain or product portfolio. In the past, product hierarchies in most companies were simple, reflecting the business at the national, brand, product group, product line, and SKU levels. These product hierarchies ranged from hundreds to a few thousand SKUs, spanning a small number of countries or sales regions and a handful of distribution points, making them fairly easy to manage (see Figure 1.1).

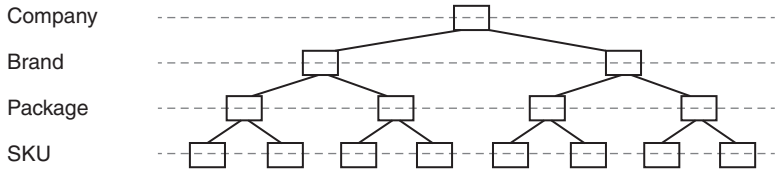

Figure 1.1 Business Hierarchy for a Beverage Company in the 1990s

During the past two decades, however, many industries have gone through major consolidations. Larger companies found it easier to swallow up smaller companies to increase their economies of scale from a sales, marketing, and operations perspective rather than growing their business organically. They realized additional benefits as they flushed out inefficiencies in their supply chains while increasing their revenue and global reach. Unfortunately, with all this expansion came complexities in the way they needed to view their businesses.

Today, with global reach across multiple countries, markets, channels, brands, and products, the degree of granularity has escalated tenfold or more (see Figure 1.2). Product portfolios of companies have increased dramatically in size, and the SKU base of companies has expanded into the thousands and in some cases hundreds of thousands. It is not unusual to see companies with more than 10,000 SKUs that span across 100 or more countries.

Further escalation occurred as marketing departments redefined their consumer base by ethnicity, channels of distribution, and purchase behavior. The resulting increased granularity has further complicated company product hierarchies. All this proliferation in business complexity has made it difficult not only to manage the data but also to process the data in a timely manner.

Given all this complexity and increase in the number of SKUs, Excel spreadsheets are no longer viable tools to manage the demand forecasting process. Excel is simply not scalable enough to handle the data and processing requirements. Excel's analytics capabilities are limited to some time series techniques and basic simple regression

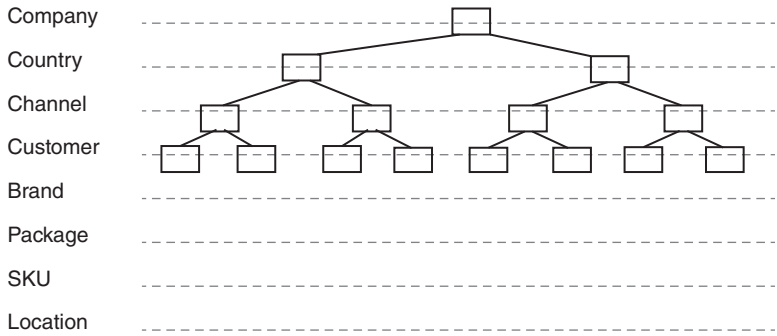

Figure 1.2 Business Hierarchy for a Beverage Company in 2013

that model trend, seasonality, and unexplainable historical patterns. Nevertheless, over 40 percent of forecasters still use Excel to do forecasting, according to several surveys conducted over the past decade by academic- and practitioner-based organizations.

In fact, a survey conducted by Purdue University and the SAS Institute found that over 85 percent of the respondents still use Excel as a workaround to existing enterprise resource planning (ERP) and supply chain management solutions due to the lack of ad hoc reporting capabilities and other related functionality.[1]

Over the past several years, the introduction of Windows NT (New Technology) servers, parallel processing, and grid computing has significantly improved the speed of processing data and running analytics on large volumes of data. Sophisticated algorithms now can be executed on a large scale using advanced statistics and business rules across company product hierarchies for hundreds of thousands of products. In fact, a large majority of products can be forecasted automatically using new enabling technologies that allow forecasters to focus on growth products that are more dynamic than mature products due to their marketplace competitiveness. Rather than spending 80 percent of their time identifying, collecting, cleansing, and synchronizing data, forecasters can now focus on those products that need more attention due to market dynamics and other related factors.

Recent development in the area of master data management and big data (both structured and unstructured) has helped standardize data structures, making it easier to manage information and untangle the years of mismanaged data storage. With all these new enhancements to data collection and processing, forecasters no longer need to worry about data quality or data availability. We can now collect, store, and process millions of data series in batch overnight and hundreds of thousands in real time in a matter of minutes and hours. Data are also streaming into enterprise data warehouses in real time via the Internet, providing forecasters with monitoring, tracking, and reporting capabilities throughout the workday.

All these improvements in data collection, storage, and processing speed have eliminated many of the barriers that prevented companies from conducting large-scale forecasts across complex supply chain networks and product hierarchies. Companies can no longer use

the excuses that data availability is limited or that running statistical models across their product portfolios takes too long. Unfortunately, companies still are having problems understanding all this information. Fortunately, uncovering actionable insights in a timely manner to make better decisions is becoming easier as significant gains have been made with new technologies in data mining and text mining. Managing information and using high-performance analytics (HPA) are enabling organizations to gain competitive advantage through timely insights and precise answers to complex business questions. These insights are being utilized to support the decision-making process and will only improve over the next several years.

ART-OF-FORECASTING MYTH

Contrary to what you have heard or believe, there is no art in forecasting; rather the art lies in statistics and domain knowledge. Domain knowledge is not the art of making judgmental overrides based on inflated bias assumptions to simple statistical baseline forecasts; domain knowledge refers to the act of defining and uncovering market opportunities based on knowledge (business acumen). In other words, forecasting uses the combination of domain knowledge (business experience) and analytics to validate or invalidate those assumptions. It is ironic that although we use exact science to manufacture products along structured guidelines with specifications that are within a .001 tolerance range, we use our gut-feeling judgment to forecast demand for those same products. I have an advanced degree in applied econometrics and more than 26 years of experience as a forecast practitioner with more than six companies, and I still cannot take my gut-feeling judgment and turn it into a number. I need to access the data and conduct the analytics to validate my assumptions. In other words, come up with a hypothesis, find the data, and conduct the analytics to determine whether you can reject the hypothesis. Then use the results to make adjustments to the statistical baseline forecast or, better yet, build those assumptions into the statistical baseline forecast by adding the additional data and revising the analytics.

Today, some global consumer packaged goods (CPG) companies like Nestlé, Dow, Cisco, and Procter & Gamble are switching to a