This volume provides a comprehensive and accessible introduction to the theory and practice of inventory control – a significant research area central to supply chain planning. The book outlines the foundations of inventory systems and surveys prescriptive analysis models for deterministic inventory control. It further discusses prescriptive analysis techniques for demand forecasting in inventory control and also examines prescriptive analysis models for stochastic inventory control.

Inventory Analytics is the first book of its kind to adopt a practical, Python-driven approach to illustrating theories and concepts via computational examples, with each model covered in the book accompanied by its Python code. Originating as a collection of self-contained lectures, this volume is an indispensable resource for practitioners, researchers, teachers, and students alike.

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Introduction

This book originates as a collection of self-contained lectures. These lectures are divided into an introduction to inventory control, which outlines the foundations of inventory systems; followed by three chapters on deterministic inventory control, demand forecasting, and stochastic inventory control.

Beside Inventory, the title of the book refers to Analytics. This is nowadays a concept that has been inflated with a plethora of meanings, so that it becomes difficult to understand exactly what each of us means when we refer to it. The Cambridge Dictionary defines Analytics as “a process in which a computer examines information using mathematical methods in order to find useful patterns.” However, this appears to be quite a restrictive definition for our purposes.

To better understand the nature of Analytics, it is useful to observe that Analytics is often broken down into three parts: descriptive, predictive, and prescriptive. Descriptive Analytics is concerned with answering the question: “what happened?” Predictive Analytics is concerned with answering the question: “what will happen?” Prescriptive Analytics is concerned with answering the question: “how can we make it happen?” These are clearly complex questions that cannot be answered by mere number crunching on a computer: to answer these questions a decision maker must leverage soft as well as hard skills.

Many tend to think that the Analytics phenomenon is a recent development related to widespread availability of computing power. However, in his work “De Inventione,” the Roman philosopher Cicero states that “there are three parts to Prudence: Memory, Intelligence, and Foresight.” It is clear that Memory is the skill required to answer the question “what happened?”; Foresight, that required to answer the question “what will happen?”; and Intelligence, that required to answer the question “how can we make it happen?” It appears then that Analytics is just a contemporary rebranding of an art that has been known for millenia. Prudentia is the ability to govern and discipline oneself by the use of reason. Inventio is the central canon of rhetoric, a method devoted to systematic search for arguments. Incidentally, inventio also means inventory. In fact, when a new argument is found, it is invented, in the sense of “added to the inventory” of arguments. Prudentia and Inventio are the foundations upon which the art of Rhetoric stands (Fig. 1).
It must not surprise us then that Analytics plays a prominent role in inventory management. Inventory management finds its roots into the practice of late medieval and early Renaissance merchants. The invention of double-entry bookkeeping (alla Veneziana) is typically attributed to Frà Luca Pacioli (c. 1447 – 19 June 1517). Pacioli leveraged Johannes Gutenberg’s new technology to disseminate and popularise accounting practices that had been in use among Venetian merchants for a long time. However, Pacioli did not simply disseminate existing practices, he reinterpreted these practices within the framework of Cicero’s rhetoric. In “De Inventione,” Cicero explains that there are five canons, or tenets, of Rhetoric: Inventio (invention), Dispositio (arrangement), Elocutio (style), Memoria (memory), and Pronuntiatio (delivery).

Pacioli’s “Tractatus de computis et scripturis” (1494, Fig. 2), is divided into two main sections: (i) the Inventory, and (ii) the Disposition — the influence of Cicero’s work is apparent. Pacioli writes: “In order to conduct a business properly a person must: possess sufficient capital or credit, be a good accountant and bookkeeper, and possess a proper bookkeeping system.” In “the Inventory,” Pacioli writes “The merchant must prepare a list of his inventory. Items that are most valuable and easier to lose should be listed first. […] The inventory should be carried out and completed in a single day. […] The inventory is to include the day that the inventory was taken, the place, and the name of the owner.” In contemporary terms, Pacioli describes a so-called “physical inventory,” the process by which a business physically reviews its entire inventory — as opposed to so-called “cycle counts,” which focus on specific subsets of items. In “the Disposition,” Pacioli describes the necessary books and rules to implement double-entry bookkeeping.

Pacioli’s work represents a quantum leap in the realm of descriptive inventory analytics, a discipline that would evolve into a fundamental part of inventory management. However, no progress was made in the realm of predictive and prescriptive inventory analytics until late 1800, when Edgeworth, in his “Mathematical Theory of Banking,” used the central limit theorem to determine cash reserves needed to satisfy random withdrawals from depositors, thus embedding a predictive probabilistic model within a prescriptive mathematical model to support inventory control decisions. From these early results, over the past 150 years, inventory control has evolved into an independent discipline. The aim of this book is to provide an introduction to this discipline.

After introducing the foundations of inventory systems, in chapter “Deterministic Inventory Control” we survey prescriptive analytics models for deterministic inventory control, in chapter “Demand Forecasting” we discuss predictive analytics techniques for demand forecasting in inventory control, which originate in the realm of time series analysis and forecasting. Finally, in chapters “Stochastic Inventory Control” and “Multi-echelon Inventory Systems” we survey prescriptive analytics models for stochastic inventory control.

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Fig. 2 Dedication page of Pacioli’s “Tractatus de computis et scripturis,” printed by Paganino de Paganini, Venice, 1494 (courtesy of Wellcome Collection).

