Carlo Alberto Magni

Investment Decisions and the Logic of Valuation

Linking Finance, Accounting, and Engineering

Springer

Carlo Alberto Magni
Department of Economics “Marco Biagi”
University of Modena and Reggio Emilia
Modena, Italy

ISBN 978-3-030-26775-9 ISBN 978-3-030-27662-1 (eBook)
https://doi.org/10.1007/978-3-030-27662-1

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

To Roberta, my capital affective project

About the Author

Carlo Alberto Magni is an Associate Professor at the Department of Economics "Marco Biagi" and the School of Doctorate E4E (Engineering for Economics—Economics for Engineering) of the University of Modena and Reggio Emilia. He has received the national qualification as full professor in Financial Markets and Institution in 2014 and in Mathematical Methods of Economics, Finance, and Actuarial Sciences in 2017.

Graduated in Economics and Business in 1989, he received his Ph.D. in Mathematics for Economic Decisions from the University of Trieste in 1996. He holds a Master in Business Administration from the University of Turin, received in 1991.

His teaching activities include engineering economics and financial management, principles and models for managerial decisions, mathematics for investment and credit, and calculus. His research areas are engineering economics, corporate finance, managerial finance, financial management, management accounting, and financial mathematics. He has written more than 100 papers and published in more than 30 different journals, including *European Journal of Operational Research*, *International Journal of Production Economics*, *Quantitative Finance*, *Journal of the Operational Research Society*, *Journal of Mathematical Economics*, *The Engineering Economist*, *European Accounting Review*, *Theory and Decision*, *Managerial Finance*, *Economic Modelling*, *Insurance: Mathematics and Economics*.

In 2011, he won the "Eugene L. Grant" Award, granted by the Engineering Economy Division of the American Society for Engineering Education (ASEE). Since 2013, he serves as area editor for *The Engineering Economist*, a joint publication of the Engineering Economy Division of ASEE and the Institute of Industrial Engineers (IIE).

Contents

Preface

> Solving a problem simply means representing it so as to make the solution transparent
>
> Simon (1981, p. 153)

This book analyzes valuation and decision-making for capital budgeting projects, also known as capital asset investments. An investment decision is a process which leads to a change in the firm's operations. It starts with the recognition of a problem that needs a solution or an opportunity to take advantage of. After investigating the technical feasibility of the project, input data are estimated which must be aggregated in a suitable *accounting-and-finance* model in order to provide a reliable valuation of the project. Valuation is meant to lead to an economically rational decision, one which is capable of *increasing the wealth* of the firm's shareholders.

Any economic entity and, in particular, a project may be viewed as a system of activities whose basic elements are: *Capital*, *income*, *cash flow*. The book is built upon the mechanics of this system. Specifically, the statics studies the forces that act upon the "economic body" at rest and determine the condition of static equilibrium; the dynamics studies the forces that govern the motion of the economic body over time. The statics is represented by the *law of conservation* (for capital, for income, and for cash flow) while the dynamics is represented by the *law of motion* (linking capital, income, and cash flow). The former has to do with a fundamental principle of accounting (accounting identity); the latter has to do with a fundamental principle of finance (time value of money).

Accounting and financial modeling of projects in this book is grounded upon such a mechanical system. We present a framework which is designed to integrate the law of conservation and the law of motion in a simple way so as to make the resulting accounting and financial modeling intuitive and easy to apply. In particular, no prerequisite of accounting and finance are required nor any knowledge of calculus.

Statics and dynamics are integrated in a matrix (the *split-screen Matrix*), a working device resulting in an innovative system of *accounting-and-finance engineering*. This system will be the beacon of a transparent and robust economic analysis of investments and will serve the purpose of linking theory and practice.

The accounting-and-finance engineering system provides the methodological framework for analyzing *capital asset projects*. Whatever the definition attached to these activities, they mostly involve the work and the expertise of one or more engineers, either for assessing the technical feasibility of some design (electrical engineers, chemical engineers, civil engineers, industrial engineers, environmental engineers, mechanical engineers, computer science engineers, etc.) or for coordinating the work of a team or managing complex systems (engineering managers, systems engineers). Therefore, to deal with capital asset projects means to deal with engineering and industrial projects.

However, this book is about *logic*. While a technical design is discipline-specific (different laws of nature are used for different designs), the *logical* design of valuation and decision is general and is not affected by the kind of activity under consideration. Therefore, since the accounting-and-finance engineering system presented in the book holds for any economic entity, the book provides the tools for modeling *any* kind of corporate decision which has an impact on the project's amount of capital, income, and cash flow, thereby including financial investments as well as real asset investments, tangible and intangible projects, manufacturing schemes as well as human resource initiatives, privately owned projects as well as (the financial aspects of) public investments. Even *firm valuation* is incorporated in the approach, for a firm may be viewed as a portfolio of projects and, symmetrically, a project may be viewed as an incremental firm. And while the estimation of the input data in terms of capital, income, and cash flow may differ across economic entities, the logical reciprocal relationships among the various types of capital, income, and cash flow do not. As a result, it suffices to change "project" with "firm" and a logical approach to firm valuation is obtained.

Logic is a tool, not an end in itself. This book does not deny the major role of informed judgment in decision-making. Quite the contrary, the book aims at providing decision-makers with a logically consistent tool which may be part of a wider process involving technical expertise, social skills, human interactions, creativity, and ethical considerations.[1]

Potential Readers

The book is addressed to three classes of readers: Practitioners, academics, and students. It is hoped that:

- practitioners (engineers, financial and operational managers, engineering managers, advisors, analysts, professionals, accountants) will find

[1]For example, to choose between a program that is expected to reduce the number of work accidents and a program that reduces water pollution and/or greenhouse gas emissions involves an ethical trade-off issue.

  - a helpful guide to the financial modeling of projects
  - user-friendly analytical tools for managing the subtleties of accounting and financial relations
  - a toolkit of techniques for carrying out an in-depth analysis of economic efficiency and for making rational decisions
  - an applicative error-free model easily convertible to spreadsheets

- academics (finance scholars, accounting scholars, engineering economists, management scientists, operations researchers, financial mathematicians) will welcome

  - the unified theory of investment decision-making
  - the robust theoretical apparatus
  - the novel way of linking finance and accounting with engineering decision-making and, more generally, corporate decision-making

- students of relevant courses (corporate finance, engineering economics, managerial finance, financial management, management accounting) will appreciate

  - the agility and easiness of the accounting and financial engineering system
  - the strong correspondence between highly theoretical notions and the ready-to-use metrics and techniques logically derived from the former
  - the use of basic algebra and simple working rules.

Some Methodological Remarks

The book is concerned with both theory and practice. No metric or technique, whether simple or complex, is reliable if it does not derive from a corpus of theoretical principles which are logically deducted from some primitive assumptions. At the same time, no theory of investment decisions is helpful if it is not applicable to the practice of real-life investment analysis and decision-making.

For this reason, the theoretical apparatus of principles, concepts, definitions of this book is in a strict correspondence with a toolkit of applicative techniques and metrics. This implies that every theoretical notion and principle presented in the book leads to one or more applicative tools, metrics, and techniques (i.e., no theoretical principle is explained without a precise correspondence in applicative terms) and every applicative tool, metric, and technique emanates from one or more theoretical principles (i.e., no metric nor technique is presented without a solid theoretical ground, logical rationale, and economic meaningfulness).

Each chapter starts with a summary and a list of skills the reader will acquire and ends with a list of key points where tables and graphs are often used in order to summarize the notions, results, relations, principles, methods, and techniques presented. They are aimed at providing snapshots of the concepts presented in the chapter for a more effective systematization of the learning material.

The book contains more than 180 guided examples. They are essential to the theory as well as the practice and are not designed to be slavish illustrations of formulas. They have several aims:

- guide the reader to a deeper understanding of the notions and methods presented
- show the application of the theory to the practice of financial modeling in a painless way
- provide conceptual insights, trigger new perspectives, introduce new notions, and stimulate comments and remarks on theory or techniques.

As such, they should be considered an essential part of the book.

Some of the worked examples are explicitly inspired by examples already presented in engineering economy textbooks or finance textbooks.

In order not to swamp the reader with excessive accuracy, which would obscure the presentation, numbers in the examples are often rounded. Some rounding errors may then arise, but the prime concern of this book is logic, not decimal place accuracy.

The book avails itself of more than 160 tables to help the reader assimilate concepts, principles, techniques, and appreciate the networks of relations involved.

The book is designed to be self-explaining and makes use of a *low-math-no-economics* teaching approach. This means that no use of calculus is made, and no prior studies of finance and accounting are required. The only prerequisite is basic (undergraduate) algebra.

Terminology

In this book, several disciplines are intertwined, which raises the major issue of using a terminology which may suit the linguistic habits and intellectual perspectives of readers of various backgrounds. This also raises an even more important problem: Different notions are sometimes referred to with the same expression or, vice versa, the same notion is sometimes referred to with different labels. This causes ambiguities, misunderstanding, frictions across scientific domains, and between academics and practitioners.

I had to make a choice capable of encompassing the multitude of notions and concepts stemming from corporate finance, accounting, and engineering economics.

The choice of some terms, expressions, definitions, and labels will meet the expectations of some while frustrating the expectations of others. To the extent that linguistic confusion would not arise and for the purpose of underlining the conceptual equivalence, in some cases I have used some terms or expressions interchangeably (e.g., *return on investment* and *return on capital*) and, in some cases, I have favored one label over other possible ones (e.g., *cash flow from operations* is favored over *capital cash flow*). Whenever labels were unavailable, as in the case of the creation of a new concept or definition, I have tried to use as intuitive a term as possible (e.g., the class of *net operating liabilities*). Several remarks are strewn over the book for clarification of terminological issues. The substantial use of symbols is meant to disambiguate, and a detailed list of notational conventions is provided at the end of the book.

Logical Structure of the Book

To describe the logical structure of the book means to describe the system of accounting-and-finance engineering that governs the process of valuation and decision-making. Figure 1 proposes a sequential chart which provides a conceptual map the reader may always turn to for a better orientation.

The starting point of the process is the determination of project input data and market input data.

Project input data consist of the differential costs (additional cost and/or cost savings), prices and quantities of new products, growth rates of costs and prices, purchases or disposals of plants and equipment, credit policy, tax rates, etc. Market input data are represented by the expected rates of return on financial assets equivalent in risk to the project's constituents (i.e., required return on assets, required return on equity, required return on debt, etc.).

The book does not deal with this first step. It assumes both project data and market data as exogenously given and guides the analyst from this point through the appraising process up to valuation and decision.

Each input belongs to one of three fundamental categories which are typical of any economic entity: *Capital*, *income*, and *cash flow*. They are ascribed to project input data and market input data, and generate two different economic systems: The project system and the benchmark system.

The project system is subjected to forces (customers, suppliers, employees, debtholders, equityholders, etc.) that determine its static equilibrium through a *law of conservation* and its dynamics through a *law of motion*. Each basic element is then broken down into subsystems (e.g., operating system, non-operating system, debt system, equity system), which are in turn broken down in further lower-level subsystems (e.g., fixed-asset system, accounts receivable system, net operating liabilities system, etc.) and gathered in the *Matrix*. The latter is a flexible machine equipped with a quadruple-entry system of working rules (*split-screen technique*) such that the entire mechanics of the project is captured by a sequence of split-screen Matrices.

The benchmark system is itself equipped with a mechanics (statics, dynamics, and associated Matrix) which is governed by the forces acting in the capital markets (demand and offer by market investors). The *Law of One Price* guarantees that all marketed assets equivalent in risk share the same equilibrium, that is, all market assets equivalent in risk have the same expected rate of return. Therefore, the benchmark system represents the expectations of the market's investors for all equivalent-risk assets.

The objective of the firm is to make decisions which increase shareholders' wealth (*rational decision-making*). This is expressed by saying that *value is created*. In order to measure shareholder value creation, the project system is compared with the benchmark system, where investors might alternatively invest their fund if they did not invest in the project system.

The project system and the benchmark system may themselves be in reciprocal equilibrium or disequilibrium. In the former case, they are expected to have equal economic profitability, which implies the firm's shareholders do not receive any additional benefit (nor loss) in undertaking the project as opposed to investing in the benchmark system. If they are in reciprocal disequilibrium, then one of the two systems increases shareholders' wealth more than the other system does. Value is created if and only if the two systems are in reciprocal disequilibrium; in particular, value is created if the disequilibrium is such that the project system's economic profitability is greater than the benchmark system's economic profitability.

The degree of disequilibrium may be measured in absolute terms (values expressed in dollars) or in relative terms (rates of return, profitability indices, benefit-cost ratios, etc.). The value of the model output (either absolute or relative) establishes whether a project should be undertaken or not and provide information on the amount of wealth increase (absolute measure) and the magnitude of the project's economic efficiency (relative measure).

However, the benchmark system is not unambiguously described. There are three ways of benchmarking a project (which refer to three ways of replicating a project by purchasing equivalent-risk assets in the capital market).

To each benchmark system, there corresponds one absolute approach and one relative approach. This brings about three pairs of valuation and decision-making approaches, each associated with a specific benchmark system. In turn, each pair is associated with one of the three basic elements:

Absolute approach	**Relative approach**	**Basic element**
Net present value (NPV)	Internal average rate of return (IARR)	Cash flow
Residual income (RI)	Average internal rate of return (AIRR)	Income
Net future value (NFV)	Aggregate return on investment (AROI)	Capital

(The widely employed internal rate of return approach is a special, rather problematic case of AIRR approach.)

The six approaches are economically rational and, therefore, financially equivalent: They lead to the same valuation and same (accept or reject) decision.

Table of Contents Overview

Chapter		Highlights
1	Dynamics. The law of motion	Presents the basic elements of an economic system (capital, income, and cash flow) and the equation of motion; introduces the income rate; distinguishes invested capital and borrowed capital; defines a project as a differential/incremental system; provides a (minimal) taxonomy for projects in terms of expansion, replacement, abandonment
2	Statics. The law of conservation	Presents the static equilibrium for each basic element; distinguishes the financial structure from the capital structure
3	Financial statements	Introduces the Matrix and the split-screen technique; examines the capital components (fixed assets, working capital, liquid assets, debt, equity), the income components (operating income, interest income, interest expense, net income), and the cash-flow components (operating and non-operating cash flow, cash flow to debt, cash flow to equity)
4	Estimating the cash flows	Employs the split-screen technique for deducting the cash flows from the accounting estimates; presents the related notions of net operating profit after taxes (NOPAT) and free cash flow (FCF); presents the mosaic of a project's cash flows
5	Valuation and value creation	Analyzes the Law of One Price and the notion of value creation; introduces a benchmark system based on replication of the project's prospective cash flows; analyzes the notions of cost of capital, minimum attractive rate of return (MARR), and net present value (NPV); defines (economically) rational decision-making
6	Project appraisal	Presents 12 discounted cash-flow valuation methods, including CFE, CCF, APV, WACC; introduces two other benchmark systems giving rise to the notions of residual income (RI) and value added (VA) (or net future value, NFV); illustrates the RI approach and the NFV approach to valuation and decision
7	The quest for a relative approach	Addresses the issue of measuring economic efficiency; argues in favor of relative measures as complements of absolute measures; anticipates the link between scale and efficiency
8	Average internal rate of return	Sets up the intuition for the notion of rate of return; provides a logical derivation of rate of return; presents the average internal rate of return (AIRR) approach, the relative counterpart of the RI approach
9	Internal rate of return	Presents the internal rate of return (IRR) approach and describes its pitfalls; shows that the IRR is a special case of the AIRR approach; illustrates the modified internal rate of return (MIRR) approach and the Teichroew-Robichek-Montalbano (TRM) model
10	IARR and AROI	Builds a genuinely internal average rate of return (IARR) which is the relative counterpart of the NPV approach; presents the aggregate return on investment (AROI), which is genuinely internal as well but is the relative counterpart of the NFV
11	Ranking projects	Develops rational ranking via relative measures of worth as well as absolute measure of worth; presents the incremental method and the direct method
12	Three decisions	Illustrates three final examples: Two engineering projects (one accept/reject decision and a choice between mutually exclusive alternatives) and a human resource initiative

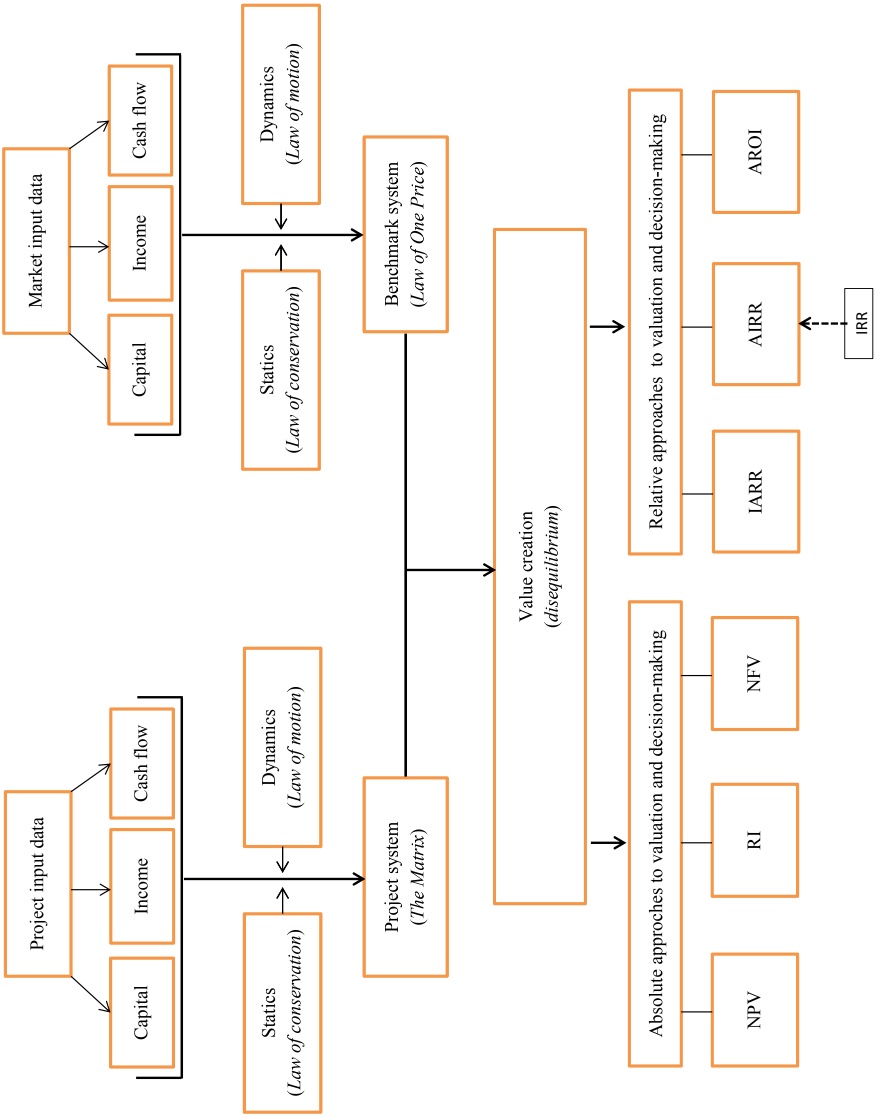

Fig. 1 Accounting-and-finance engineering system

Acknowledgements

This book originates from an invitation by Anthony Doyle, executive editor for Springer. The book would not have been written without his invitation, so I thank him for this opportunity (and for his patience). Actually, I must add that the book would not have been written if I had not attended, 30 years ago, the outstanding lectures by Lorenzo Peccati, who first opened my mind on financial mathematics, a quite obscure world before meeting him. He and his inspiring works have contributed to direct my researches toward capital budgeting analysis. His appreciation of my research results and his constant support in these years have been very important. I am deeply grateful to him.

In recent years, the appreciation of my work by Joseph Hartman has been essential to head towards engineering economics. I would like to express my gratitude to him. I thank Thomas Boucher for giving me the opportunity of gaining experience as an area editor of *The Engineering Economist*. Both Joe and Tom have contributed to my ever-increasing interest in linking engineering and economic decision-making. On the "engineering" part, I also wish to thank Gordon Hazen, who has always been supportive of my approach to financial efficiency.

My inveterate, almost philosophical attitude to symmetry has brought me to accounting, which I see as a means for unifying different valuation methods and decision criteria. This disposition has led me to the authoritative, enlightening papers by Ken Peasnell and has triggered fruitful exchanges with him. I am very grateful to him for his support and encouragement to my effort of establishing links between accounting and finance.

It is precisely the "finance turn" taken by my researches which has set up the conditions to get in touch with various scholars involved in firm valuation as well as project appraisal. In particular, I would like to thank John Martin, whose books have helped me make my way in the world of corporate valuation theory. A special thank goes to Ignacio Vélez-Pareja; we have had long, vibrant discussions about firm and project valuation and fertile exchanges on several topics related to corporate finance and financial modeling. I thank Yoram Kroll and Moshe Ben-Horin for their appreciation of my work and for their hospitality. I am much obliged to

Moshe, who meticulously read, evaluated, and analyzed the whole book. His rigorous and cogent remarks on each and every part of it have been extremely important to improve the presentation and to test the solidity and transparency of my approach to valuation and decision.

I am indebted to “eagle-eyed” Andrea Marchioni, who painstakingly read the book and supplied a great help in editing it, detecting many annoying typos and errors; he examined its preciseness and analytical consistency and we had lively and useful exchanges on the various topics treated in the book.

I thank Franco Leone, accountant, for some clarifications of accounting subtleties and for his unfailing friendship. A last, personal thank is due to my mother-in-law, Carla, for his sympathetic support during these years.