Chapter 7: CAPM

Some questions in this problem set are taken from the book *Investment Science* from Luenberger.

Question1 (Capital Market Line):

1. (Capital market line) Assume that the expected rate of return on the market portfolio is 23% and the rate of return on T-bills (the risk-free rate) is 7%. The standard deviation of the market is 32%. Assume that the market portfolio is efficient.

(a) What is the equation of the capital market line?

(b) (i) If an expected return of 39% is desired, what is the standard deviation of this position? (ii) If you have $1,000 to invest, how should you allocate it to achieve the above position?

(c) If you invest $300 in the risk-free asset and $700 in the market portfolio, how much money should you expect to have at the end of the year?

(a) The capital market line is defined by:

$$\bar{r}_i = E(r_i) = r_F + \frac{E(r_M) - r_F}{\sigma_M}\sigma_i = 0.07 + \frac{0.23 - 0.07}{0.32}\sigma_i$$

(b) (i)

$$0.39 = 0.07 + \frac{0.23 - 0.07}{0.32}\sigma_i \implies \sigma_i = \frac{0.32^2}{0.23 - 0.07} = 0.64$$

(ii)

$$\omega \times 0.07 + (1 - \omega) \times 0.23 = 0.39 \implies \omega = -1$$

$$\implies \text{Borrow \$1000 at the risk-free rate and invest \$2000 into the market}$$

(c)

$$300 \times (1.07) + 700 \times (1.23) = 1182$$

Question 2 (A small world):

2. (A small world) Consider a world in which there are only two risky assets, A and B, and a risk-free asset F. The two risky assets are in equal supply in the market; that is, $M = \frac{1}{2}(A + B)$. The following information is known: $r_F = .10$, $\sigma_A^2 = .04$, $\sigma_{AB} = .01$, $\sigma_B^2 = .02$, and $\bar{r}_M = .18$

(a) Find a general expression (without substituting values) for σ_M^2, β_A, and β_B.

(b) According to the CAPM, what are the numerical values of $\bar{r}_A$ and $\bar{r}_B$?

(a) We use the calculation rules for the covariance of a sum of random variables (https://en.wikipedia.org/wiki/Covariance)

Luenberger Chapter 7 Problem 7

Eli Gershon,Uri Shaked,Isaac Yaesh

Luenberger Chapter 7 Problem 7:

Observer Design for Nonlinear Systems Pauline Bernard,2019-02-01 Observer Design for Nonlinear Systems deals with the design of observers for the large class of nonlinear continuous time models It contains a unified overview of a broad range of general designs including the most recent results and their proofs such as the homogeneous and nonlinear Luenberger design techniques The book starts from the observation that most observer designs consist in looking for a reversible change of coordinates transforming the expression of the system dynamics into some specific structures called normal forms for which an observer is known Therefore the problem of observer design is broken down into three sub problems What are the available normal forms and their associated observers Under which conditions can a system be transformed into one of these forms and through which transformation How can an inverse transformation that recovers an estimate in the given initial coordinates be achieved This organisation allows the book to structure results within a united framework highlighting the importance of the choice of the observer coordinates for nonlinear systems In particular the first part covers state affine forms with their Luenberger or Kalman designs and triangular forms with their homogeneous high gain designs The second part addresses the transformation into linear forms through linearization by output injection or in the context of a nonlinear Luenberger design and into triangular forms under the well known uniform and differential observability assumptions Finally the third part presents some recently developed methods for avoiding the numerically challenging inversion of the transformation Observer Design for Nonlinear Systems addresses students and researchers looking for an introduction to or an overview of the state of the art in observer design for nonlinear continuous time dynamical systems The book gathers the most important results focusing on a large and diffuse literature on general observer designs with global convergence and is a valuable source of information for academics and practitioners

H-infinity Control and Estimation of State-multiplicative Linear Systems Eli Gershon,Uri Shaked,Isaac Yaesh,2005-06-24 Multiplicative noise appears in systems where the process or measurement noise levels depend on the system state vector Such systems are relevant for example in radar measurements where larger ranges involve higher noise level This monograph embodies a comprehensive survey of the relevant literature with basic problems being formulated and solved by applying various techniques including game theory linear matrix inequalities and Lyapunov parameter dependent functions Topics covered include convex H2 and H infinity norms analysis of systems with multiplicative noise state feedback control and state estimation of systems with multiplicative noise dynamic and static output feedback of stochastic bilinear systems tracking controllers for stochastic bilinear systems utilizing preview information Various examples which demonstrate the applicability of the theory to practical control engineering problems are considered two such examples are taken from the aerospace and guidance control areas   *Data Transportation and Protection* John E. Hershey,Rao K. Yarlagadda,2012-12-06 A new breed of engineer is developing in our contemporary society These engineers are concerned

with communications and computers economics and regulation These new engineers apply themselves to data to its pack aging transmission and protection They are data engineers Formal curricula do not yet exist for their dedicated development Rather they learn most of their tools on the job and their roots are in computer engineering communications engineering and applied mathe matics There is a need to draw relevant material together and present it so that those who wish to become data engineers can do so for the betterment of themselves their employer their country and ultimately the world for we share the belief that the most effective tool for world peace and stability is neither politics nor armaments but rather the open and timely exchange of information This book has been written with that goal in mind Today numerous signs encourage us to expect broader information exchange in the years to come The movement toward a true Integrated Services Digital Network ISDN is perhaps the clearest of these Also the development offormal protocol layers reflects both a great deal of brilliance and compromise and also the desire for a common language among data engineers **Geophysical Inverse Theory** Robert L. Parker,1994-06-05 In many physical sciences the most natural description of a system is with a function of position or time In principle infinitely many numbers are needed to specify that function but in practice only finitely many measurements can be made Inverse theory concerns the mathematical techniques that enable researchers to use the available information to build a model of the unknown system or to determine its essential properties In Geophysical Inverse Theory Robert Parker provides a systematic development of inverse theory at the graduate and professional level that emphasizes a rigorous yet practical solution of inverse problems with examples from experimental observations in geomagnetism seismology gravity electromagnetic sounding and interpolation Although illustrated with examples from geophysics this book has broad implications for researchers in applied disciplines from materials science and engineering to astrophysics oceanography and meteorology Parker s approach is to avoid artificial statistical constructs and to emphasize instead the reasonable assumptions researchers must make to reduce the ambiguity that inevitably arises in complex problems The structure of the book follows a natural division in the subject into linear theory in which the measured quantities are linear functionals of the unknown models and nonlinear theory which covers all other systems but is not nearly so well understood The book covers model selection as well as techniques for drawing firm conclusions about the earth independent of any particular model **Financial Economics, Risk and Information** Marcelo Bianconi,2011-08-23 Financial Economics Risk and Information presents the fundamentals of finance in static and dynamic frameworks with focus on risk and information The objective of this book is to introduce undergraduate and first year graduate students to the methods and solutions of the main problems in finance theory relating to the economics of uncertainty and information The main goal of the second edition is to make the materials more accessible to a wider audience of students and finance professionals The focus is on developing a core body of theory that will provide the student with a solid intellectual foundation for more advanced topics and methods The new edition has streamlined chapters and topics with new sections on portfolio choice under alternative information structures

The starting point is the traditional mean variance approach followed by portfolio choice from first principles The topics are extended to alternative market structures alternative contractual arrangements and agency dynamic stochastic general equilibrium in discrete and continuous time attitudes towards risk and towards inter temporal substitution in discrete and continuous time and option pricing In general the book presents a balanced introduction to the use of stochastic methods in discrete and continuous time in the field of financial economics **Computational Inelasticity** J.C. Simo,T.J.R. Hughes,2006-05-07 A description of the theoretical foundations of inelasticity its numerical formulation and implementation constituting a representative sample of state of the art methodology currently used in inelastic calculations Among the numerous topics covered are small deformation plasticity and viscoplasticity convex optimisation theory integration algorithms for the constitutive equation of plasticity and viscoplasticity the variational setting of boundary value problems and discretization by finite element methods Also addressed are the generalisation of the theory to non smooth yield surface mathematical numerical analysis issues of general return mapping algorithms the generalisation to finite strain inelasticity theory objective integration algorithms for rate constitutive equations the theory of hyperelastic based plasticity models and small and large deformation viscoelasticity Of great interest to researchers and graduate students in various branches of engineering especially civil aeronautical and mechanical and applied mathematics **Control and Filtering for Semi-Markovian Jump Systems** Fanbiao Li,Peng Shi,Ligang Wu,2016-11-04 This book presents up to date research developments and novel methodologies on semi Markovian jump systems S MJS It presents solutions to a series of problems with new approaches for the control and filtering of S MJS including stability analysis sliding mode control dynamic output feedback control robust filter design and fault detection A set of newly developed techniques such as piecewise analysis method positively invariant set approach event triggered method and cone complementary linearization approaches are presented Control and Filtering for Semi Markovian Jump Systems is a comprehensive reference for researcher and practitioners working in control engineering system sciences and applied mathematics and is also a useful source of information for senior undergraduates and graduates in these areas The readers will benefit from some new concepts new models and new methodologies with practical significance in control engineering and signal processing **Introduction to Optimization Methods** P. Adby,2013-03-09 During the last decade the techniques of non linear optim ization have emerged as an important subject for study and research The increasingly widespread application of optim ization has been stimulated by the availability of digital computers and the necessity of using them in the investigation of large systems This book is an introduction to non linear methods of optimization and is suitable for undergraduate and post graduate courses in mathematics the physical and social sciences and engineering The first half of the book covers the basic optimization techniques including linear search methods steepest descent least squares and the Newton Raphson method These are described in detail with worked numerical examples since they form the basis from which advanced methods are derived

Since 1965 advanced methods of unconstrained and constrained optimization have been developed to utilise the computational power of the digital computer The second half of the book describes fully important algorithms in current use such as variable metric methods for unconstrained problems and penalty function methods for constrained problems Recent work much of which has not yet been widely applied is reviewed and compared with currently popular techniques under a few generic main headings vi PREFACE Chapter I describes the optimization problem in mathemat ical form and defines the terminology used in the remainder of the book Chapter 2 is concerned with single variable optimization The main algorithms of both search and approximation methods are developed in detail since they are an essential part of many multi variable methods **Parimutuel Applications In Finance** Ken Baron,Jeffrey Lange,2006-11-28 Financial intermediaries typically offer derivatives to their customers only when they can hedge the exposures from these transactions Baron and Lange show that parimutuel auctions can be used by financial intermediaries to offer derivatives without exposing themselves to risk

Introduction to Mathematical Economics M.C. Kemp,Y. Kimura,2012-12-06 Our objectives may be briefly stated They are two First we have sought to provide a compact and digestible exposition of some sub branches of mathematics which are of interest to economists but which are underplayed in mathematical texts and dispersed in the journal literature Second we have sought to demonstrate the usefulness of the mathematics by providing a systematic account of modern neoclassical economics that is of those parts of economics from which jointness in production has been excluded The book is introductory not in the sense that it can be read by any high school graduate but in the sense that it provides some of the mathematics needed to appreciate modern general equilibrium economic theory It is aimed primarily at first year graduate students and final year honors students in economics who have studied mathematics at the university level for two years and who in particular have mastered a full year course in analysis and calculus The book is the outcome of a long correspondence punctuated by periodic visits by Kimura to the University of New South Wales Without those visits we would never have finished They were made possible by generous grants from the Leverhulme Foundation Nagoya City University and the University of New South Wales Equally indispensible were the expert advice and generous encouragement of our friends Martin Beckmann Takashi Negishi Ryuzo Sato and Yasuo Uekawa Analysis and Design of Descriptor Linear Systems Guang-Ren Duan,2010-09-14 Descriptor linear systems theory is an important part in the general field of control systems theory and has attracted much attention in the last two decades In spite of the fact that descriptor linear systems theory has been a topic very rich in content there have been only a few books on this topic This book provides a systematic introduction to the theory of continuous time descriptor linear systems and aims to provide a relatively systematic introduction to the basic results in descriptor linear systems theory The clear representation of materials and a large number of examples make this book easy to understand by a large audience General readers will find in this book a comprehensive introduction to the theory of descriptive linear systems Researchers will find a comprehensive description of the most recent results in this

theory and students will find a good introduction to some important problems in linear systems theory **Aircraft Control Allocation** Wayne Durham,Kenneth A. Bordignon,Roger Beck,2017-01-17 Aircraft Control Allocation Wayne Durham Virginia Polytechnic Institute and State University USA Kenneth A Bordignon Embry Riddle Aeronautical University USA Roger Beck Dynamic Concepts Inc USA An authoritative work on aircraft control allocation by its pioneers Aircraft Control Allocation addresses the problem of allocating supposed redundant flight controls It provides introductory material on flight dynamics and control to provide the context and then describes in detail the geometry of the problem The book includes a large section on solution methods including Banks method a previously unpublished procedure Generalized inverses are also discussed at length There is an introductory section on linear programming solutions as well as an extensive and comprehensive appendix dedicated to linear programming formulations and solutions Discrete time or frame wise allocation is presented including rate limiting nonlinear data and preferred solutions Key features Written by pioneers in the field of control allocation Comprehensive explanation and discussion of the major control allocation solution methods Extensive treatment of linear programming solutions to control allocation A companion web site contains the code of a MATLAB Simulink flight simulation with modules that incorporate all of the major solution methods Includes examples based on actual aircraft The book is a vital reference for researchers and practitioners working in aircraft control as well as graduate students in aerospace engineering *Optimal Control for Chemical Engineers* Simant Ranjan Upreti,2016-04-19 This self contained book gives a detailed treatment of optimal control theory that enables readers to formulate and solve optimal control problems With a strong emphasis on problem solving it provides all the necessary mathematical analyses and derivations of important results including multiplier theorems and Pontryagin s principle The text presents various examples and basic concepts of optimal control and describes important numerical methods and computational algorithms for solving a wide range of optimal control problems including periodic processes *Foundations of Deterministic and Stochastic Control* Jon H. Davis,2012-12-06 Control theory has applications to a number of areas in engineering and communication theory This introductory text on the subject is fairly self contained and consists of a wide range of topics that include realization problems linear quadratic optimal control stability theory stochastic modeling and recursive estimation algorithms in communications and control and distributed system modeling In the early chapters methods based on Wiener Hopf integral equations are utilized The fundamentals of both linear control systems as well as stochastic control are presented in a unique way so that the methods generalize to a useful class of distributed parameter and nonlinear system models The control of distributed parameter systems systems governed by PDEs is based on the framework of linear quadratic Gaussian optimization problems Additionally the important notion of state space modeling of distributed systems is examined Basic results due to Gohberg and Krein on convolution are given and many results are illustrated with some examples that carry throughout the text The standard linear regulator problem is studied in the continuous and discrete time cases followed by a discussion of dual

filtering problems Later chapters treat the stationary regulator and filtering problems using a Wiener Hopf approach This leads to spectral factorization problems and useful iterative algorithms that follow naturally from the methods employed The interplay between time and frequency domain approaches is emphasized Foundations of Deterministic and Stochastic Control is geared primarily towards advanced mathematics and engineering students in various disciplines **Observers in Control Systems** George Ellis,2002-10-16 Observers are digital algorithms that combine sensor outputs with knowledge of the system to provide results superior to traditional structures which rely wholly on sensors Observers have been used in selected industries for years but most books explain them with complex mathematics Observers in Control Systems uses intuitive discussion software experiments and supporting analysis to explain the advantages and disadvantages of observers If you are working in controls and want to improve your control systems observers could be the technology you need and this book will give you a clear thorough explanation of how they work and how to use them Control systems and devices have become the most essential part of nearly all mechanical systems machines devices and manufacturing systems throughout the world Increasingly the efficiency of production the reliability of output and increased energy savings are a direct result of the quality and deployment of the control system A modern and essential tool within the engineer s kit is the Observer which helps improve the performance and reduce the cost of these systems George Ellis is the author of the highly successful Control System Design Guide Second Edition Unlike most controls books which are written by control theorists and academics Ellis is a leading engineer designer author and lecturer working in industry directly with the users of industrial motion control systems Observers in Control Systems is written for all professional engineers and is designed to be utilized without an in depth background in control theory This is a real world book which will demonstrate how observers work and how they can improve your control system It also shows how observers operate when conditions are not ideal and teaches the reader how to quickly tune an observer in a working system Software Available online A free updated and enhanced version of the author s popular Visual ModelQ allows the reader to practice the concepts with Visual ModelQ models on a PC Based on a virtual laboratory all key topics are demonstrated with more than twenty control system models The models are written in Visual ModelQ and are available on the Internet to every reader with a PC Teaches observers and Kalman filters from an intuitive perspective Explains how to reduce control system susceptibility to noise Shows how to design an adaptive controller based on estimating parameter variation using observers Shows how to improve a control system s ability to reject disturbances Key topics are demonstrated with PC based models of control systems The models are written in both MatLab and ModelQ models are available free of charge **Microprocessors in Signal Processing, Measurement and Control** S.G. Tzafestas,2012-12-06 In racent years the LSI technology has witnessed a revoluti onary development and allowed substantial reductions in the size and cost of digital logic circuitry Computer system building blocks have progressed from the level of discrete components to the level of complex ICs involving many logic circuits on a single chip The invention and

wide applica tions of microprocessors have changed the philosophy of the signal processing measurement and control engineering fields The microprocessor based digital signal processing systems and controllers have replaced the conventional ones based on standard analog and digital computing equipment The first microprocessors and on chip computers have appeared towards the end of 71 beginning 72 Their evolution since then and the number of applications in which they have been utilized have both been extremely spectacular New system concepts and hardware software tools are steadily under development to sup port the microprocessor in its multiple and complex tasks The goal of this book is to provide a cohesive and well balan ced set of contributions dealing with important aspects and applications of microprocessors to signal processing measu rement and system control The majority of contributions in clude sufficient review material and present rather complete treatments of the respective topics   Advanced Microeconomics for Contract, Institutional, and Organizational Economics W. Bentley MacLeod,2022-04-05 A graduate textbook on microeconomics covering decision theory game theory and the foundations of contract theory with a unique focus on the empirical This graduate level text on microeconomics covering such topics as decision theory game theory bargaining theory contract theory trade under asymmetric information and relational contract theory is unique in its emphasis on the interplay between theory and evidence It reviews the microeconomic theory of exchange from the ground up aiming to produce a set of models and hypotheses amenable to empirical exploration with particular focus on models that are useful for the study of contracts institutions and organizations It explores research that extends price theory to the exchange of commodities when markets are incomplete discussing recent developments in the field Topics covered include the relationship between theory and evidence decision theory as it is used in contract theory and institutional design game theory axiomatic and strategic bargaining theory agency theory and the class of models that are considered to constitute contract theory with discussions of moral hazard and trade with asymmetric information and the theory of relational contracts The final chapter offers a nontechnical review that provides a guide to which model is the most appropriate for a particular application End of chapter exercises help students expand their understanding of the material and an appendix provides brief introduction to optimization theory and the welfare theorem of general equilibrium theory Students are assumed to be familiar with general equilibrium theory and basic constrained optimization theory   **Experimental Methods in Kinetic Studies** Bohdan Wojciechowski,Norman Rice,2003-02-20 This book is a guide to kinetic studies of reaction mechanisms It reviews conventional reactor types and data collection methods and introduces a new methodology for data collection using Temperature Scanning Reactors TSR It provides a theoretical and practical approach to temperature scanning TS methodology and supports a revival of kinetic studies as a useful approach to the fundamental understanding of chemical reaction mechanisms and the consequential reaction kinetics Describes a new patented technology Of interest to industrial and academic researchers in the fields of kinetics and catalysis No existing competitor for this title   **Applied Control** S.

G. Tzafestas,1993-04-29 This book provides a representative set of modern methodologies and applications including new topics in the field discussing a wide range of issues and treating them in depth The book describes analytical processes for fault diagnosis of automatic control systems examines modern sensors and actuators as well as measurement techniques considers multidimensional feedback control and image restoration procedures among other topics   Systems Engineering for Power United States. Division of Electric Energy Systems. Systems Management & Structuring,1978

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