PREFACE

The objectives of writing this book are twofold, firstly, to demonstrate the significance of optimal growth economics for optimal growth programming, operational social choice, economic planning, and forecasting dynamic macroeconomic systems, and secondly, to propose the establishment of optimal growth economics as a separate discipline in economics.

There is a body of work relating to optimal economic growth that began with the seminal work of Cambridge philosopher, mathematician and economist Frank Ramsey on optimal savings (1928) and was further established in Dorfman, Samuelson and Solow (1958) and Chakravarty (1969), among others. The study of optimal growth has also been a notable tradition of many great economists such as Samuelson, Solow, Tinbergen, Sen, Koopmans, and Malinvaud and is primarily concerned with the formulation of an optimal growth program, plan or strategy within a suitable mathematical optimisation method. Traditionally optimal growth economics has been treated as a branch of welfare economics with predominant academic and theoretical interests. However, this position has changed fundamentally during recent years and optimal growth economics has emerged as an important discipline in applied welfare economics.

It is now an established practice in economics to utilise an applied growth optimisation modelling framework to address important issues in growth and many other areas of economics. A considerable number of economists have adopted traditional optimal economic growth models to incorporate the emerging issues of different branches in economics including finance, human capital development, political economy, energy, natural resources, environmental economics, sustainability and uncertainty in applied models (for example Nordhaus (1994) and Solow (1974) among others). An important area of application of optimal growth economics is the study of sustainability of growth. As optimal growth economics has introduced and formalised the concept of sustainability in the 'golden rule' paradigm (optimal sustainable growth), it is the best forum to study this issue.

This book *Optimal Growth Economics* is an attempt to continue this tradition by evaluating and extending the application of optimal growth programming to address important contemporary issues of growth economics with national, global, environmental and ecological growth models, of both deterministic and stochastic variety, in a single volume. This task involved resolving many important issues in the formulation of an optimal growth program or plan such as: (1) the specification of the elements of an optimal growth program; (2) addressing the issues in growth economic theories, policies, etc.; (3) sustainability and optimality of growth; and (4) modelling of optimal sustainable growth requiring an extension of the traditional framework of optimal growth models.

Some of the contemporary issues in economic growth that have been analysed extensively relate to: the determinants of economic growth; the issues about limits to economic growth at the national and global level; the choice of objectives of growth policies; and the consistency of sustainability and optimality of economic growth. However, there are still many unresolved issues of the theory and practice of the formulation of optimal growth programs and plans.

The book has performed several tasks and made some contributions to resolving these emerging issues. This book has:

1) investigated the emerging issues in economic growth through numerical implementation of optimal growth models;
2) proposed the establishment of optimal growth economics as a *separate and practical discipline* such as the discipline of cost-benefit analysis;
3) proposed an alternative optimal growth model which incorporates various components/sub-systems of society such as the economic, social, environmental, financial and legal sub-systems. The associated growth strategies embedded in this system model are included and are effective for sustainable economic growth. This is different from, and an extension to, the traditional optimal growth modelling framework of the existing literature;
4) addressed the issues in the theory and practice of optimal growth economics which have emerged since Ramsey;
5) reported some new contributions in several areas of optimal growth modelling: (a) algorithms (discretisation method), (b) a computer program (the SCOM program), and (c) new sustainability models and computational methods (Craven and Islam 2001a, Islam and Craven forthcoming); and

6) analysed the welfare economic implications of, and the possibility for operational modeling of the social choice problem by adopting optimal growth economics based on an integration of various disciplines such as moral philosophy, sociology, ecology, etc.

To investigate the implications of the issues discussed above and to develop the required models, the structure of the book has been designed as noted below:

- Chapter Two: Aggregative theoretical growth models, which are then extended in Chapters Three to Ten.
- Chapter Three: Computational methods for optimal growth models.
- Chapter Four: Models showing the interdependence between optimal growth and the social discount rate (SDR).
- Chapter Five: Optimal growth models with the environment.
- Chapter Six: National optimal growth models.
- Chapter Seven: Global growth models.
- Chapters Eight and Nine: Optimal growth models addressing the issue of climate change and ecology respectively.
- Chapter Ten: Optimal growth models under uncertainty.

The book has two parts, A and B. Part A of the book contains the framework of concepts and methods and Part B reports some real life or realistic optimal growth models.

It must be stressed that this book is not on optimal growth theory, but is rather on optimal growth economics covering both theories and operational aspects of optimal growth economics (programming, empirical, computational and applications). The focus of this study is to show the operational feasibility and significance of optimal growth economics in formulating optimal sustainable growth and welfare programs, plans and forecasts. Therefore, it presents a survey of optimal growth theories and models, computerised growth models, discussions of solution algorithms and includes policy and forecasting applications of optimal growth models. Different models have produced substantially different types of growth dynamics, and different patterns of optimal growth paths. While neoclassical growth models have shown stable sustained growth paths, other models have predicted sometimes unstable, unsustainable growth.

The book has followed the traditional phases and aspects of theoretical and applied optimal growth modelling studies. Applied numerical optimal growth modelling involves the specification of quantitative computable optimal growth models, the development of algorithms and computer

programs and the computer implementation of the model. This modelling process has been followed for all applied computerised mathematical modelling studies in different chapters of this book.

The achievements of this book are that it is the first study on optimal economic growth that contains a comprehensive survey and analysis of optimal growth theory as well as its many applications. It contains a large number of real life or realistic applications of optimal growth economics, and presents the developments of the discipline historically while focusing on contemporary issues and studies, including the issues of sustainability of optimal growth and social welfare. The book has also made various contributions to the literature.

The main *characteristics and contributions* of the book are that it has:[1]

1) comprehensively investigated the emerging issues in growth economics with a special emphasis on the issues of sustainable growth of real life economies under different conditions by adopting optimal growth models;
2) developed, adopted and applied theoretical and mathematical methods to a wide range of real life conditions requiring social choice, policy and economic planning, and forecasting;
3) made some extensions to existing literature on the computation of optimal growth models (algorithm and software usage);
4) filled a gap in the literature by providing an academic course outline of optimal growth economics;
5) provided a comprehensive survey of the literature; and
6) raised many issues which may stimulate further research involving international cooperation.

A further detailed discussion of the achievements, contributions and limitations of this book is given in Chapter Twelve.

This book includes many examples of rigorous research studies and can be used as a reference book by researchers in the area of optimal growth economics – it contains a good survey of issues, theories and policies, and the development of a considerable number of models in this area. It can be used as a sole text for a course on optimal growth economics at the Masters or Doctoral level. It will also be of importance to academics, practitioners, policy makers, and postgraduate students in the fields of general economics,

[1]Readers familiar with the literature in the area of optimal growth economics will be able to identify and evaluate the nature of contributions made in this study.

growth economics, welfare economics, computational economics, resource and environmental economics and planning, mathematical economics, and operations research. Readers from all countries with different economic and social systems may find the book useful and interesting.

As this is an interdisciplinary study, readers of this book are expected to have some familiarity with the following subjects: Dynamic Optimisation (Sengupta and Fanchon 1997); Mathematical Economics (Intriligator 1971); Mathematical Programming (Taha 1992); Growth Economics (Burmeister and Dobell 1970); Economic Planning (Chakravarty 1969); Environmental Economics (Siebert 1998); Economics of Uncertainty (Laffont 1989; Varian 1992); Ecological Economics (Van den Bergh 1992); Welfare Economics (Boadway and Bruce 1984; Arrow et al. forthcoming; Laffont 1988); GAMS (Brooke et al. 1997) and Computational Economics (Amman et al. 1996; Thompson and Thore 1992). References cited in the bibliography of the book may be consulted for further information in the above areas and other related areas covered in this book. Non-technical readers may skip some of the mathematically oriented sections of the book without losing continuity of the main arguments and findings of the book.

The author thanks many experts in the relevant fields, especially Professors William Nordhaus, David Kendrick, Bruce Craven, Peter Dixon, John Quiggin, J. van den Bergh, Neville Norman and Drs. R. Guest, J. Smulders, and Hieu Trinh who have read or reviewed different sections of the book. I am especially indebted to Prof William Nordhaus for assisting me in various ways in undertaking this study; this book owes considerably to his work in this area.

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Some materials of this book originated as lecture notes for a doctoral level subject on computational economics/economic modelling. I wish to thank students in these lectures for providing many useful feedback comments on the materials presented here. I am currently supervising ten doctoral students, most of whom are undertaking research on issues or by adopting methodologies discussed in this book. The interdependence of our research interests and the influence of my joint research with them, on this study are evident from the citations of our joint research in this book especially with Jim Gigas, Matthew Clarke, Christina Mak, Jamie Sanderson and Sami Choi.

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I have previously published papers and chapters of books in the area of optimal and sustainable growth. It may, however, be stressed that *(a) the context of the use of, (b) the implications of, and (c) the focus of conclusions drawn from* the materials in this book are different from those of my previous publications.

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