Money and Macroeconomic Dynamics

Accounting System Dynamics Approach

Edition 5.1

Prof. Kaoru Yamaguchi, Ph.D.

Graduate School of Economics
Social Sciences University of Ankara, Turkey

Copyright © 2013, 2020 by Kaoru Yamaguchi

Edition 1.0 is published in November, 2013.
Edition 1.1 is e-published in February, 2014.
Edition 2.0 is e-published in August, 2014.
Edition 3.0 is e-published in August, 2016.
Edition 3.1 is e-published in November, 2016.
Edition 3.2 is e-published in August, 2017.
Edition 4.0 is e-published in January, 2019.
Edition 5.0 is e-published in April, 2020.
Edition 5.1 is e-published in August, 2020.

Japan Futures Research Center
Awaji Island, 656-1325
Japan

Web: www.muratopia.net
Email: director-jfrc@muratopia.net
sd-info@muratopia.net

All rights reserved
Cover Design: Daichi Yamaguchi,
MS in Environmental Engineering

ISBN 978-4-907291-01-3

(Typeset on August 1, 2020)

Preface to the Edition 5

After a completion of the edition 4.0 as an electronic book in Jan. 2019, I had an opportunity to provide lectures based on this book for advanced Ph.D. and Master classes in economics at the Social Sciences University of Ankara. This opportunity gave me a chance to revisit Chapters 1 through 8 in detail, and revise them whenever needed. I do truly appreciate for valuable comments given by the Ph.D. and Master students in my classes.

Since no hard copies of the book have been made available except its first edition in Japan in 2013, I have distributed pdf files of the book, lecture by lecture, in my classes. Gradually I have strongly felt a need for hard copies of my book as a quick reference in my classes. Under such circumstances, I happen to obtain a possible publication of this book. I'm very grateful for this unexpected opportunity.

At the moment of writing this preface, a new-type of coronavirus (officially called Covid-19), which broke in Wuhan, China, in Dec. 2019, has spread at an unexpected speed world-wide in 3 months and became a global pandemic. This global pandemic is slowing global economic activities all of sudden, and is feared to be a trigger of yet another Great Depression since 1929. Following the Great Depression of 1929, two proposals were made, to avoid such socio-economic disasters, by the two great economists in those days; The General Theory of Employment, Interest and Money by John M. Keynes (1935) and 100% Money by Irving Fisher (1935). This book tries to integrate these two preeminent proposals, and provide an alternative solution against a looming Great Depression. It is the author's genuine hope that this edition would become a new economic vaccine against such a looming calamity.

April 1, 2020

Kaoru Yamaguchi, Ph.D.

At the Social Science University of Ankara

Republic of Turkey

Preface to the Edition 4

Since the publication of first edition of this book in Nov. 2013, more than 5 years have passed. I'm pleased to share with the reader that the macroeconomic method of Accounting System Dynamics first proposed in the book is getting accepted, though gradually, among young economists and researchers of macaroeconomics who are not fully content with the current mainstream macroeconomic modeling such as Neoclassical DSGE and New Keynesian models.

Since the publication of the first edition, our economic world is experiencing the so-called *Blockchain Revolution*. Our first edition through edition 3.1 have overlooked this revolution which is drastically changing the way we theorize macroeconomic activities. Under these circumstances, I have strongly felt a necessity to reconsider futures of the public money system in the age of blockchain revolution.

In this edition of 4.0, therefore, I have wholly paid attention to electronic public money, or crypto-public money, as *money of the futures*, following the discussions on public money system in the previous editions. Specifically, Part V of Electronic Public Money is newly added to this edition. It consists of a single additional chapter, Chapter 17, that demonstrates electronic public money as money of the futures.

With this new addition, I have strongly felt that my long journey toward a better world through Public Money System becomes immensely closer to its final destination. The remaining fine-tuning works will be left to the younger generations of economists and researchers.

January 26, 2019

Kaoru Yamaguchi, Ph.D.

At the Social Science University of Ankara

Republic of Turkey

Preface

My Off-Road Journey for A Better World

Futures Studies

In early 1980's, I was told by one of the graduate colleagues at the University of California, Berkeley, that if I continue the research involving Marx and Keynes in addition to neoclassical theory, I would never get a good job offer in the United States. He was right. It was a time for Reganomics which has eventually evolved to the era of globalization in 1990's. Paying little attention to his thoughtful suggestion, I pursued my Ph.D. thesis on the subject "Beyond Walras, Keynes and Marx - Synthesis in Economic Theory Toward a New Social Design", which, alas, became a start of my off-road journey. Main part of the thesis was luckily published with the same title [89], yet it has been left unnoticed among main stream economists.

When I started teaching at the Dept. of Economics, University of Hawaii at Manoa, I almost lost my energy to continue the research on neoclassical mathematical theory for academic survival, because the theory seemed to be totally detached from the economic reality. It was in those discouraged days when my introduction to the futures studies and Prof. Jim Dator, then secretary general of the World Futures Studies Federation, took place by chance in Hawaii in 1987. Upon arrival to Japan next year, I immediately joined the Federation, and became very active on futures studies for more than ten years since then.

Among the activities of futures studies I have been involved, a major one was the organization of futures seminar series in Awaji Island, Japan, with an objective to establish a future-oriented higher institution dubbed the Network University of the Green World (http://www.muratopia.org/ NUGW). The seminars had been held for seven years from 1993 through 1999, then suspended due to the lack of fund. In the book based on the first seminar in 1993, I have proclaimed that

> Thus, what has been missing in industrial-age scientific research, and hence in the academic curricula of present-day higher institutions, is a study of interrelated wholeness and interdependences [92, p.200].

In order to fill the missing niche, I have tried, with a help by the seminar participants, including Novel laureate Jerome Karle, to establish a new wholistic

field of study dubbed FOCAS, meaning Future-Oriented Complexity and Adaptive Studies, in vain. Yet, my conviction on the need for such futures studies for higher education continued to remain as worth being upheld. Faced with the threat of our survival due to climate changes and environmental disasters, future-oriented studies of interrelated wholeness and interdependence is, I believe, more urgently needed for solving these complex problems, since solutions offered by fragmented professionals at the current higher institutions might be the causes of another problems as Asian wisdom connotes. For our survival and sustainability, we need future-oriented higher education which provides wholistic visions and solutions to the present complex problems caused by fragmented science and technology of the present-day higher education. This conviction became a fruit of reward for me at the cost of abandoning neoclassical economic research in a traditional academic stream.

System Dynamics

Throughout the future-oriented activities later on, I was luckily led to the systems view, specifically a method called system dynamics, by chance. It seemed to me a totally new field of study that makes a heavy use of computer simulation for analyzing dynamic behaviors of system structures in physics, chemistry, engineering, environmental studies, business and economics, and public policies, to name a few, in a uniform fashion. In short, its methodology can uniformly cover many fragmented fields of studies, and in this sense it seemed for me to be able to share a similar interdisciplinary vision with future-oriented studies. After many years' frustration on the futures studies, I've jumped in the fieled by attending its international conference in Istanbul, Turkey, in 1997. Since then I have been continually attending the system dynamics conferences up to the the present day.

It didn't take much time to realize that, due to its interdisciplinary nature, system dynamics is also facing a similar difficulty in finding an academic position as a discipline in the current extremely fragmented higher educational system, as future-oriented studies have been suffering similarly. In other words, system dynamics and futures studies can have no comfortable places in the current universities. The only difference is the use of computer in the former, and the use of our brain in the latter.

Hence, it seemed to me that future-oriented studies and system dynamics constitute two major fields of future's higher education, using our brain on the one hand and computer on the other hand for a study of interrelated wholeness and interdependence in order to attain human and environmental sustainability. In fact, it has been repeatedly argued at the international conferences whether system dynamics is merely a tool or discipline. For me it seemed to be not to the point and accordingly a fruitless argument.

On the contrary, the following description by Prof. Jay Forrester, a founder of system dynamics, on the nature of system dynamics looked to me to the point.

> Such transfer of insights from one setting to another will help to break down the barriers between disciplines. It means that learning in one field becomes applicable to other fields. There is now a promise of reversing the trend of the last century that has been moving away from the "Renaissance man" toward fragmented specialization. We can now work toward an integrated, systemic, educational process that is more efficient, more appropriate toward a world of increasing complexity, and more compatible with a unity in life [22].

It is a useless effort to search for an appropriate academic citizenship at the current fragmented higher education. In this sense, it seems to be a right choice to introduce the visions and methods of system dynamics to the K-12 education where academic fragmentation does not yet break down into the learning process. The reader may visit a creative learning Web site for its successful introduction at http://clexchange.org.

I felt I have finally been led to a right truck, after more than a decade-long off-road journey, toward a better world. If I had stayed at the economics profession, I would have never encountered system dynamics as most economists are currently still unaware of it. What I have learned from system dynamics is the importance of system design.

My continuing off-road journey got refurbished with this spirit of system design. In the falls of 1998 and 1999, I had a chance to visit MIT where I was introduced systems thinking and system dynamics for the first time as if I was a first-hand learning student by Prof. John Sterman and his doctorate students as well as Prof. Jay Forrester and his undergraduate team of Road Map project (educational self-learning system dynamics program through Web). This became my off-road journey of no return from system dynamics in my profession.

Accounting System Dynamics

Instead of being forced to stay in the economics profession, I was luckily given a chance to teach system dynamics at two management schools in Japan; first at the Osaka Sangyo University in Osaka, then Doshisha Business School in Kyoto. System dynamics obtained its first citizenship in this way as academic subject to be taught in the fragmented higher educational system in Japan.

Eventually, as a faculty member of management and business schools, I strongly felt it necessary to cover accounting system in my system dynamics class. Yet, my search for SD-based accounting system turned out to be unsuccessful, giving me an incentive to develop a SD method of modeling financial statements and accounting system from a scratch. I started working on the SD-based accounting system in the summer of 2001 when I was spending relatively a quiet time on a daily rehabilitation exercise in order to recover from the physical operation on my shoulder in June of the same year. This retreat environment provided me with an opportunity to read books on accounting intensively. My readings mainly consisted of the introductory books such as [32], [42], [48], [78] and [79], since my knowledge of accounting was limited in those

days[1]. Through such readings, I have been convinced that system dynamics approach is very effective not only for understanding the accounting system, but modeling many types of business activities. This conviction fruitfully resulted in my presentation on the principle of accounting system dynamics at the 21st international conference of the System Dynamics Society in New York in 2003 [94], which became a turning point in my off-road journey.

Rekindled in Berkeley, California

In the same summer of 2003, I was luckily offered an 8 months' sabbatical leave, and came back to Berkeley in almost 18 years since I left in 1986, this time as a visiting scholar at the Haas School of Business, not the Economics Department. My old friend, Nobie Yagi, from Berkeley days kindly provided his second house on his site for my family's stay, which gave me a good opportunity to talk with him almost daily. He received Ph.D. in finance and options trading from Berkeley around the same time as I did.

Conversation with him, together with my research environment at the business school rekindled my interest in economics, specifically macroeconomics and finance again. Even so, in those days I have already taken an off-road journey away from main stream economics, and decided to investigate it from my off-road side way. Specifically, I resolved to start reconstructing macroeconomic theories on the basis of the principle of accounting system dynamics which was completed in the same summer.

Since then, being led by the inner logic of accounting system dynamics and macroeconomics, I have spent almost my entire off-road journey on a step-by-step construction of macroeconomic models, which turned into a series of presentation of papers such as [96], [97], [98] and [99]. This series of macroeconomic modeling was completed in 2008 as [100] with a follow-up analytical refinement method of price adjustment mechanism in [101] next year.

An Oasis in Wellington, New Zealand

Second good luck visited me on my off-road journey as two months' short sabbatical leave in 2009 at the Victoria Management School, Victoria University of Wellington, New Zealand. Prof. Robert Y. Cavana, a well-known leading scholar in system dynamics, kindly hosted my visit. This good luck enabled me to review the above paper series uniformly for the publication of this book. Almost daily conversation with him over lunch, as well as a lovely research environment in Wellington, encouraged me to keep working on the draft. Without this stopover in New Zealand as an oasis in my off-road journey, the draft would not have been completed.

[1]In addition to these books, a paper dealing with corporate financial statements [3] was published in 2002. However, current research for modeling financial statements is independently carried out here with a heuristic objective in mind.

National Model

I was a late comer to the research community of system dynamics. While my step-by-step macroeconomic modeling was advancing, some researchers have kindly suggested at the conferences that I should review the research papers on the National Model project that was led by Prof. Jay Forrester with several Ph.D. students at MIT.

Unfortunately, the national model itself was not available and its related papers were scattered around. Under such situation, my survey managed to cover the following papers [18], [19], [20], [21], [23], [24], [25], [26], [27], [28], [29], [30], [36], [40], [70], [71]. Yet, the review of these papers only gave me an impression as if I were, with my eyes closed, touching various parts of an elephant without knowing what the elephant looks like. During the 23rd international conference of System Dynamics Society in New York, July, 2005, in which I presented a SD-based Keynesian model, I have strongly felt that my research cannot advance without understanding a whole picture of National Model, because my modeling approach, I feared, might have been already taken by the National Model project team.

Without losing time, in September of the same year, I visited Prof. Jay Forrester in his office at MIT. We spent almost two hours on discussing about his National Model. He told me that the national model is still going on, and I may have no chance to take a look at it until it's completed. Even so, the conversation turned out to be very fruitful to me, out of which I got convinced that my modeling approach on the basis of accounting system dynamics is quite different from his modeling method. This conviction gave me an energy to continue my off-road journey in my own way. At the same time, I truly hoped that the national model would be completed in the near future.

In the spring of 2007, I was invited to review the Ph.D. dissertation by David Wheat at the University of Bergen, Norway, whose title is "The Feedback Method: - A System Dynamics Approach to Teaching Macroeconomics [85]". His model, written by Stella software, seemed to me to be a simple version of the National Model. In this sense it became the first complete macroeconomic model ever presented to the public, and his effort should be congratulated. In the following year, at the 26th international conference of System Dynamics Society, Athens, Greece, I have presented a complete macroeconomic model, written by Vensim, on the basis of accounting system dynamics [100].

US Congressional Briefing

After a completion of my macroeconomic model in 2009, I was taking a rest in a foggy day at a vista point on my off-road journey. Financial crisis triggered by the bankruptcy of Lehman Brothers in 2008, followed by a series of government debt crises in the US and EU, blew away thick fog and all of a sudden a lofty peak of better world I've been searching for emerged in front of me. It was a peak of new macroeconomic system of public money. When I looked back the trail I followed so far, it turned out to be a macroeconomic system of debt

money.

A glimpse of this new peak of hope drove me again into writing papers [102] and [103] toward a better world. On the next day of the presentation of my paper [103] at the 29th International Conference of the System Dynamics Society in Washington DC, that is, on July 26, 2011, I was invited by the Congressman Dennis Kucinich to present the findings of my macroeconomic simulations on the workings of public money system at the US Congressional Briefing. This unexpected invitation recharged my driving energies toward a steeper trail on my off-road journey.

The peak of the better world is a green and sustainable world. It will be described in the last chapters of 12, 13, 14 and 15 (Part IV). Coincidentally this turned out to be the reinvigorated world of MuRatopian economy I've vehemently pursued in my dissertation in 1980's as a new social design.

Beyond

While working on my dissertation on "Beyond Walras, Keynes and Marx", I was once visited by a daydream that an academic torch of economic thoughts has been handed over from Karl Marx to John M. Keynes and from Keynes to me. It occured unexpectedly when I happened to realize the fact that Keynes was born in the year 1883 when Marx passed away, and I was born in the year 1946 when Keynes passed away. Since then I've been enslaved by a sense of scientific mission, though the reader may laugh at its mirage, that I should carry on and go beyond their economic thoughts for a better world.

Modern macroeconomic foundation was laid by the Keyne's esteemed book: The General Theory of Employment, Interest and Money published in 1936. When I encountered the title for the first time as a young student of economics, I got puzzled and confused by the order of "employment, interest and money". Nowadays, students may have no such puzzles because almost all macroeconomic textbooks start with the analysis of GDP that determines the level of employment, followed by the aggregate demand that constitutes GDP such as consumption and investment. Then interest and money supply are introduced as a determinat of investment. Under the Keynesian analytical framework, money has been all the time treated as an adjunct to the macroeconomic system; that is, money has been regarded as an exogenous entity, not as an endogenous one. This may be the reason why employment comes first, followed by interest and money comes last in the title of the book.

On the contrary, the title of this book, though it deals with similar subjects as Keynes, starts with the analysis of money and interest, followed by macroeconomic dynamics. The book is founded on the method of Accounting System Dynamics. Accounting system has been the most rigorous method in social science, while system dynamics has been the robust foundation of dynamic analysis (that is, differential equations) in natural science since Newton. In this sense, this methodology could be said to provide the most robust tool for analyzing the structure of macroeconomic behaviors. This analytical method that is being applied to the macroeconomic analysis has revealed that *money matters by all*

means or *money is all the time endogenous* as the reader may be convinced by going through the book. In other words, without money comprehensive macroeconomic models are first of all unable to be constructed. Money continues to sit in the center of all macroeconomic behaviors. This is why the title of this book becomes "Money and Macroeconomic Dynamics" In the Keynesian sense, the title of the book may be called "The General Theory of Money, Interest and Employment. The torch of Keynes' General Theory is now to be carried over in a thoroughly reversed order!

Moreover, it lights up the macroeconomic systems analyzed in Part II and III of the book as a *debt money* system in which Walras, Keynes and Marx used to live and we are living today, while it illuminates the macroeconomic systems designed in Part IV as a *public money* system in which we'll live in the near future as a sustainable world beyond the current debt money system.

Let me stop my off-road journey at this point. It is my hope that the reader will continue this off-road journey to the summit, so that, as travelers and hikers increase, it eventually becomes a main road journey for a better and green world.

With many thanks to those who guided me and offered a cordial help during my off-road journey, on my birthday:

June 24, 2013

Kaoru Yamaguchi, Ph.D.

At the Japan Futures Research Center

Awaji Island, Japan

Acknowledgments

First of all, I would like to give my cordial thanks to those who have helped me during my off-road journey: Jim Dator, Matthias Ruth, Jay Forrester, John Sterman, Nobie Yagi, Robert Y. Cavana, David Wheat, Andrew Ford, Dennis Kucinich.

I have started using this draft as a main reference in my MBA classrooms since 2009. Feedback comments and suggestions from my students, Hisashi Deguchi, Hiroyuki Hori and Nobuo Nishi, turned out to be very helpful to improve the draft, for which I do express my acknowledgments. Prof. Yutaka Takahashi has read the draft and given me some valuable comments, to whom I am very grateful.

Meanwhile, I have taken opportunities to offer the SD workshops at the 28th International Conference of the System Dynamics Society, in Seoul, Korea, July 29, 2010, at the 29th Conference in Washington DC, USA, July 28, 2011, and at the 30th Conference in St. Gallen, Switzerland, July 26, 2012, under the theme: An Introduction to Macroeconomic Modeling – Accounting System Dynamics Approach. Many SD researchers and students from the conferences have participated in the workshops and gave me very valuable suggestions and comments on my analytical method of macroeconomic modeling, convinced me simultaneously that it's on the right track, for which I truly thank them all.

Additionally I was given invaluable opportunities to present the contents in Part IV: Macroeconomic Systems of Public Money at the 6th, 7th and 8th Annual AMI (American Monetary Institute) Monetary Conferences in Chicago, USA, in 2010, 2011, and 2012. I truly thank Stephen Zarlenga, the director of AMI, and Jamie Walton, the AMI researcher, for providing these opportunities, and conferences participants, specifically Joe Bongiovanni, for their worthy comments and suggestions. These turned out to be very prolific for deepening my analyses.

Finally, I do warmheartedly appreciate the patience of my families; Naomi, Daichi and Yokei for my relinquishing fun time with them on holidays due to my off-road journey. Latest edition 5.0 would not have been completed without intensive and in-depth exchanges of ideas with Yokei Yamaguchi, a young researcher at the Japan Futures Research Center.

Gassho!

A Quick Tour of the Off-Road Journey

Let us now begin with a quick tour of the author's off-road journey. The reader is recommended to follow chapter by chapter to fully comprehend the macroeconomic model-building structures based on the accounting system dynamics approach, because most models built in the book are constructed step by step by following the previous models. Your feedbacks are mostly appreciated by the author through his email at kaoru.yamaguchi@asbu.edu.tr or kaoru3-860@muratopia.net.

Part I Accounting System Dynamics

Chapter 1 introduces the author's way of understanding system dynamics from a dynamics viewpoint. Those who have its background may still find some useful features of system dynamics.

Chapter 2 compares general equilibrium price adjustment mechanism of demand and supply with off-equilibrium adjustment mechanism that is made possible by the system dynamics method of incorporating inventory. This off-equilibrium approach becomes a point of departure of our macroeconomic analysis from the neoclassical equilibrium analysis.

Chapter 3 combines the principles of system dynamics with those of accounting system. The unified principle is called the Principle of Accounting System Dynamics, which constitutes one of the most robust foundations for the analysis of macroeconomic dynamics.

Part II Debt Money System

Chapter 4 overviews macroeconomic system of debt money. This chapter investigates a simple capitalist market economy consisting of traditional budget equations by applying the principle of accounting system dynamics. The economy is constructed on the framework of monetary flow such that the so-called Say's law holds; that is, a well-known Goodwin Growth Cycle model.

Chapter 5 explores the nature of money and its creation through a fractional reserve banking under current debt money system. Functional-money creation processes under both flow and stock approaches are comparatively investigated step by step from the case of the gold standard to the case of loan to banks, then loan to government.

Chapter 6 continues the analysis of money creation from the previous chapter, and discusses how money stock is endogenously determined by the demand for borrowing money by producers, households and government by running the ASD models of money creation in the previous chapter. Endogenous destruction and instability of money stock are explored.

Chapter 7 expands the analysis of money to interest and examines the equity distribution between non-financial sector and banks. It is then applied to the monetary Goodwin model to find out if this integrated monetary economy with interest triggers business cycles into economic recessions.

Part III Macroeconomic Systems of Debt Money

Chapter 8 discusses a typical Keynesian macroeconomic model of aggregate demand where Say's law no longer holds by applying system dynamics adjustment process. Then, a Keynesian IS-LM equilibrium model is explored within the framework of monetary circulation among producers, consumers, government and banks.

Chapter 9 integrates real part and monetary part of macroeconomic activities analyzed in the previous chapter by distinguishing nominal and real units of macroeconomic variables such as nominal vs real interest rates and nominal vs real GDP.

Chapter 10 incorporates population dynamics and labor market with the introduction of Cobb-Douglas production function. This chapter completes our comprehensive macroeconomic analysis under the debt money system. It reveals an inescapable accumulation of government debt even under an ideal equilibrium path in the real sector.

Part IV Open Macroeconomic Systems of Debt Money

Chapter 11 sets off macroeconomic analyses of open debt money systems through chapter 11. This chapter explores a dynamic determination of foreign exchange rate in an open macro economy in which goods and services are freely traded and financial capital flows efficiently for higher returns.

Chapter 12 expands the comprehensive macroeconomic model in chapter 9 to the open macroeconomies on the basis of the framework developed in the previous chapter. It provides a complete generic macroeconomic model of open macroeconomies as a closed system of debt money.

Part V Macroeconomic Systems of Public Money

Chapter 13 sets off our macroeconomic analyses of public money systems through chapter 15. This chapter discusses how the government debt crisis is structurally built in the current macroeconomic system of debt money. Then it demonstrates how the government debt can be liquidated under an alternative macroeconomic system of public money, proposed by the American Monetary Act, by revisiting the integrated macroeconomic model developed in chapter 8.

Chapter 14 analyzes the workings of a public money system under the most comprehensive open macroeconomies developed in chapter 11. Then it is demonstrated that under the public money system government debt can be liquidated without triggering recession, unemployment and inflation both in domestic and foreign economies.

Chapter 15 explores monetary and financial stability under the public money system in comparison with the current debt money system by constructing a simplified macroeconomic model with a stock approach of credit creation presented in chapter 5.

Chapter 16 searches for a better design of our macroeconomic system for our sustainable futures. First, it examines the public money system in comparison with the current debt money system. Then, the MuRatopian economy that was introduced in 1988 is revisited as a complementary system. Finally, the integrated system of these two is proposed as the best design of macroeconomic system for our sustainable futures.

Chapter 17 proposes a transition process from the debt money system to the public money system by constructing a simple macroeconomic model based on the accounting system dynamics. The model briefly handles main features of the debt money system, in 8 steps, that cause "booms and depressions", debt accumulation and failures of recent quantitative easing financial policy. It then offers a transition process to the public money system in 6 steps.

Part VI Electronic Public Money

Chapter 18 explores a new public money system in the age of blokchain and crypto-money. Electronic Public Money in the form of crypto-money is posed to be *money of the futures*.

ASD Models and Figures in the book

The reader is highly encouraged to confirm the simulation results in the book by running the companion models mentioned chapter by chapter. In this way, the reader may enjoy running simulations according to his or her own interest in macroeconomic behaviors.

All ASD models used in the book are freely available at

http://www.muratopia.org/Yamaguchi/MacroBook.html
http://www.muratopia.net/YamaguchiKaoru/Yamaguchi/MacroBook.html

Some Figures in thebook may be unfortunately too small to identify the details. Accordingly, they are also freely available for the convenience of the reader at the same Web sites as above.

Edition Notes

Edition 1.1 Figure 3.10 is revised. Minor type errors in Preface, Chapters 1, 9 and 15 are corrected.

Edition 2.0 Chapter 16 is newly added. Figure 11.6 is revised. Minor type errors are corrected.

Edition 3.0 Chapter 5 is fully revised with money creation models of both flow and stock approaches. Terminologies such as "money supply" and "monetary base" in the Chapter are replaced with "money stock" and "base money", respectively.

Edition 3.1 Chapter 3 is partly revised with revised definitions of Asset Management Ratios.

Edition 3.2 Classification of Money (Table 5.2 in Chapter 5) is slightly revised. Type errors in Bibliography are corrected.

Edition 4.0 Chapters 18 is newly added to the book as "Part V: Electronic Public Money". Preface to the edition 4.0 is newly written.

Edition 5.0 Subsection of Chapter 1 (Present Values) is added. Chapters 4, 5 and 7 are substantially revised. Chapter 6 is newly augmented. IS-LM analysis in Chapter 8 is expanded. Minor changes in Chapters 2, 3, 4, 9 and 16 are made.

Edition 5.1 Chapters 5 and 6 are revised with new classification tables of money stock that include front face and back face of money definition.

Postscript

Due to the budgetary constraint[2], the author was unable to get an editorial help in English. Accordingly, the reader would be kindly asked to accept the author's apologies for some clumsy writings that still remain in this book.

[2]This was caused by the sudden termination of the author's academic position, in March 2013, at the Graduate School of Business, Doshisha University, Kyoto, due to the use of system dynamics in his MBA lecture of Business Economics. Concerned researchers of system dynamics and economics overseas sent letters of petition to the president and dean of the university to stop the violation of academic freedom in vain.

Contents

I Accounting System Dynamics **1**

1 System Dynamics **3**
1.1 Language of System Dynamics . . . 3
1.2 Dynamics . . . 5
1.2.1 Time . . . 5
1.2.2 Stock . . . 5
1.2.3 Stock-Flow Relation . . . 6
1.2.4 Integration of Flow . . . 8
1.3 Dynamics in Action . . . 9
1.3.1 Constant Flow . . . 10
1.3.2 Linear Flow of Time . . . 10
1.3.3 Nonlinear Flow of Time Squared . . . 13
1.3.4 Random Walk . . . 15
1.4 System Dynamics . . . 16
1.4.1 Exponential Growth . . . 16
1.4.2 Present Values . . . 19
1.4.3 Balancing Feedback . . . 20
1.5 System Dynamics with One Stock . . . 23
1.5.1 First-Order Linear Growth . . . 23
1.5.2 S-Shaped Limit to Growth . . . 24
1.5.3 S-Shaped Limit to Growth with Table Function . . . 25
1.6 System Dynamics with Two Stocks . . . 26
1.6.1 Feedback Loops in General . . . 26
1.6.2 S-Shaped Limit to Growth with Two Stocks . . . 27
1.6.3 Overshoot and Collapse . . . 28
1.6.4 Oscillation . . . 29
1.7 Delays in System Dynamics . . . 31
1.7.1 Material Delays . . . 31
1.7.2 Information Delays . . . 33
1.8 System Dynamics with Three Stocks . . . 35
1.8.1 Feedback Loops in General . . . 35
1.8.2 Lorenz Chaos . . . 36
1.9 Chaos in Discrete Time . . . 39
1.9.1 Logistic Chaos . . . 39

1.9.2 Discrete Chaos in S-shaped Limit to Growth 40

2 Demand and Supply 43
2.1 Adam Smith! 43
2.2 Unifying Three Schools in Economics 45
2.3 Tâtonnement Adjustment by Auctioneer 47
2.4 Price Adjustment with Inventory 52
2.5 Logical vs Historical Time 55
2.6 Stability on A Historical Time 57
2.7 A Pure Exchange Economy 58
2.7.1 A Simple Model 58
2.7.2 Tâtonnement Processes on Logical Time 60
2.7.3 Chaos Triggered by Preferences 64
2.7.4 Off-Equilibrium Transactions on Historical Time 65
2.8 Co-Flows of Goods with Money 66

3 Accounting System Dynamics 73
3.1 Introduction 73
3.2 Principles of System Dynamics 75
3.3 Principles of Accounting System 76
3.4 Principle of Accounting System Dynamics 80
3.5 Accounting System Dynamics Simplified 82
3.6 Accounting System Dynamics in Action 86
3.7 Making Financial Statements 98
3.8 Ratio Analysis of Financial Statements 100
3.9 Toward A Corporate Archetype Modeling 103

II Debt Money System 107

4 Macroeconomic System Overview 109
4.1 Macroeconomic System 109
4.2 A Capitalist Market Economy 110
4.3 Modeling a Capitalist Market Economy 112
4.4 Fund-Raising Methods 114
4.5 A Goodwin Growth Cycle Model 118
4.6 A Monetary Goodwin Model 124
4.7 A Monetary Goodwin Model with Interest 129

5 Money and Its Creation 139
5.1 What is Money? 139
5.1.1 Aristotle's Definition of Money 139
5.1.2 Issuance of Legal Tender 141
5.1.3 Classification of Money 142
5.1.4 Base Money as Legal Tender 143
5.1.5 Bank Deposits as Functional-Money 145

5.1.6 Debt Money vs Public Money System 147
5.2 Classification of Money in Japan 148
5.2.1 Money Stocks in 2018 148
5.2.2 Money Stocks between 1980 and 2018 150
5.3 Flow Approach of Functional-Money Creation 152
5.3.1 Three Sectors and Twofold Double Entry Rule 152
5.3.2 A *Fractional Reserve* Banking: Flow Approach 153
5.3.3 Money Convertibility Coefficient 158
5.3.4 Accounting Presentation of Flow Approach 160
5.4 Stock Approach of Functional-Money Creation 162
5.4.1 A *Fractional Reserve* Banking: Stock Approach 162
5.4.2 Accounting Presentation of Stock Approach 164
5.4.3 Masqueraded Economists for Flow Approach 165
5.5 Functional-Money Creation under Gold Standard 167
5.5.1 Flow Approach Simulations 167
5.5.2 Stock Approach Simulations 175
5.5.3 Limit to the Gold Standard System 178
5.6 Functional-Money Creation out of Discount Loans to Banks 180
5.6.1 Discount Loans: Flow Approach Simulations 180
5.6.2 Discount Loans: Stock Approach Simulations 184
5.7 Functional-Money Creation out of Loans to Government 184
5.7.1 A Complete Money Creation Model: Flow Approach . . . 184
5.7.2 A Complete Money Creation Model: Stock Approach . . 190
5.8 Identical Creations of Functional-Money 193

6 Money as Total Debts **199**
6.1 Money Stock $\simeq$ Total Debts 199
6.2 Money Stock $\simeq$ Total Debts: A Case in Japan 204
6.3 Destruction of Money Stock 207
6.3.1 Causes of Monetary Destruction 207
6.3.2 How Destruction of Money Stock Takes Place? 209
6.4 Open Market Operations as QE 211
6.5 Monetary Instability 213
6.6 "100%Money" for Monetary Stability 214

7 Interest and Equity **219**
7.1 What is Interest? 219
7.2 Money and Interest under Gold Standard 221
7.2.1 (1) Flow Approach 221
7.2.2 (1) Stock Approach 223
7.3 Money and Interest under Loans to Banks 225
7.3.1 (2) Flow Approach 225
7.3.2 (2) Stock Approach 226

7.4 Money and Interest under Government Debt 227
7.4.1 (3) Flow Approach 227
7.4.2 (3) Stock Approach 228
7.5 Money and Interest under Open Market Operations 230
7.5.1 Flow Approach: Phases (4) & (5) 230
7.5.2 Stock Approach: Phases (4) & (5) 232
7.6 Equity Distribution under 100% Money 234
7.7 Interest and Sustainability 236

III Macroeconomic Systems of Debt Money 239

8 Aggregate Demand Equilibria 241
8.1 Macroeconomic System Overview 241
8.2 A Keynesian Model 242
8.3 Aggregate Demand (IS-LM) Equilibria 248
8.4 Modeling Aggregate Demand Equilibria 252
8.5 Behaviors of Aggregate Demand Equilibria 258
8.6 Limitations of the IS-LM Analysis 266
8.6.1 Failure of Monetary Policy 266
8.6.2 Erroneous Money Hypothesis of the Great Depression . . 268
8.7 Neoclassical Policy of Price Flexibility 268
8.8 A Comprehensive IS-LM Model 274
8.9 Conclusion 279

9 Integration of Real and Monetary Economies 287
9.1 Macroeconomic System Overview 287
9.2 Changes for Integration 288
9.3 Transactions Among Five Sectors 295
9.4 Behaviors of the Integrated Model 302
9.5 Conclusion 314

10 A Macroeconomic System 317
10.1 Macroeconomic System Overview 317
10.2 Production Function 317
10.3 Population and Labor Market 323
10.4 Transactions Among Five Sectors 325
10.5 Behaviors of the Complete Macroeconomic Model 333
10.6 Conclusion 346

IV Open Macroeconomic Systems of Debt Money 349

11 Balance of Payments and Foreign Exchange 351
11.1 Open Macroeconomy as a Mirror Image 351

11.2 Open Macroeconomic Transactions 352
11.3 The Balance of Payments 357
11.4 Determinants of Trade 362
11.5 Determinants of Foreign Investment 365
11.6 Dynamics of Foreign Exchange Rates 367
11.7 Behaviors of Current Account 370
11.8 Behaviors of Financial Account 372
11.9 Foreign Exchange Intervention 376
11.10Missing Feedback Loops 378
11.11Conclusion 381

12 Open Macroeconomies as A Closed System 383
12.1 Open Macroeconomic System Overview 383
12.2 Transactions in Open Macroeconomies 384
12.3 Behaviors of Open Macroeconomies 402
12.4 Where to Go from Here? 405
12.5 Conclusion 408

V Macroeconomic Systems of Public Money 409

13 Designing A Public Money System 411
13.1 Search for An Alternative System 411
13.2 Debt Crises As A Systemic Failure 412
13.3 A Public Money System 417
13.4 Macroeconomic System of Debt Money 423
13.5 Behaviors of A Debt Money System 427
13.6 Macroeconomic System of Public Money 434
13.7 Behaviors of A Public Money System 438
13.8 Conclusion 442

14 Workings of A Public Money System 443
14.1 Modeling A Debt Money System 443
14.2 Behaviors of A Debt Money System 446
14.3 Modeling A Public Money System 453
14.4 Behaviors of A Public Money System 458
14.5 Public Money Policies 460

15 Monetary and Financial Stability 467
15.1 The Chicago Plan Revisited 467
15.2 Debt vs Public Money Systems Simplified 469
15.3 Behaviors of A Debt Money System 474
15.4 Behaviors of A Public Money System 487

16 Public Money and Sustainability **495**
16.1 Public vs Debt Money System Structures 495
16.2 Public vs Debt Money System Behaviors 499
16.3 The MuRatopian Economy Revisited 503
16.4 The Green Village(MuRatopia) Economy 507

17 A Transition to the Public Money System **515**
17.1 Volatile Behaviors of Debt Money System 515
17.2 A Transition to the Public Money System 533

VI Electronic Public Money **547**

18 Electronic Public Money **549**
18.1 The Year 2008 550
18.2 Money Creation Revisited 552
18.2.1 Public Money and Debt Money 552
18.2.2 Money as Legal Tender 553
18.2.3 Bank Deposits as Functional-Money 553
18.3 Debt Money System Revisited 554
18.3.1 The Origin: Fractional Reserve Banking 554
18.3.2 Structure of Debt Money System 555
18.3.3 System Behaviors: Four Built-in Failures 556
18.4 Payments under Debt Money System 559
18.4.1 With Cash and Electronic Cash 559
18.4.2 With Deposits through Banks as Intermediaries 561
18.4.3 With Deposits: Non-banks as Intermediaries 562
18.5 Public Money System Revisited 568
18.5.1 The Origin: Chicago Plan and 100% Money 568
18.5.2 Structure of Public Money System 569
18.5.3 System Behaviors: Four Failures Getting Fixed 572
18.5.4 Transition Steps to the Public Money System 574
18.5.5 Payments under Public Money System 574
18.6 Bitcoin and Blockchain Technology 575
18.6.1 System Structure of Bitcoin 575
18.6.2 Payments with Bitcoin 575
18.6.3 How Bitcoin Transactions Work? 576
18.7 Challenges facing Bitcoin 579
18.8 Electronic Public Money System 581
18.8.1 Integrated Public Money and Blockchain 581
18.8.2 Structure of EPM System 581
18.8.3 System Behaviors of EPM Systems 583
18.9 Blockchain-based Money Classified 584
18.9.1 Classification of Money after the Year 2008 584
18.9.2 Crypto-coin 585
18.9.3 Central Bank Cryptocurrency (CBCC) 587

18.9.4 Crypto-token 589
18.10EPM as Money of the Futures 591
18.10.1 Payments under EPM 591
18.10.2 Design Configuration of EPM Protocol 592

List of Figures

1.1 Language of System Dynamics 4
1.2 Stock-Flow Relation 7
1.3 Linear Flow of Time 11
1.4 Linear Flow and Stock 11
1.5 Nonlinear Flow and Stock 14
1.6 Random Walk 16
1.7 Stock-Dependent Feedback 17
1.8 Examples of Exponential Feedback 19
1.9 Present Value 19
1.10 Present Values: Discrete vs Continuous 20
1.11 Balancing Feedback 21
1.12 Examples of Balancing Feedback 22
1.13 Exponential Decay 22
1.14 Examples of Exponential Decay 22
1.15 First-Order Linear Growth Model 23
1.16 Exponential Growth and Decay 24
1.17 S-shaped Growth Model 24
1.18 S-Shaped Limit to Growth 1 25
1.19 S-Shaped Limit to Growth Model with Table Function 26
1.20 S-Shaped Limit to Growth 2 with Table Function 26
1.21 Feedback Loops in General 27
1.22 S-shaped Growth Model 27
1.23 S-Shaped Limit to Growth 3 28
1.24 Overshoot & Collapse Model 29
1.25 Overshoot & Collapse Behavior 29
1.26 An Oscillation Model 30
1.27 Oscillation under Euler Method 30
1.28 Oscillation under Runge-Kutta2 Method 30
1.29 Structure of Delays 31
1.30 First-Order Material Delays 32
1.31 Second-Order Material Delays 32
1.32 First-Order Information Delays 33
1.33 Second-Order Information Delays 34
1.34 Adaptive Expectations Model for Random Walk 34

1.35 Adaptive Expectations Behaviors for Random Walk 35
1.36 Feedback Loop in General 35
1.37 Lorenz Feedback Loop 37
1.38 Lorenz Chaos 37
1.39 Sensitive Dependence on Initial Conditions 38
1.40 Chaos in Logistic Function 40
1.41 Chaos in S-shaped Limit to Growth 40

2.1 Price Mechanism of Demand and Supply 44
2.2 Demand and Supply Functions 48
2.3 Auctioneer's Tâtonnement Model 49
2.4 Stability of Equilibrium 50
2.5 Chaotic Price Behavior 51
2.6 Short-side Transaction Model and Inventory 52
2.7 Price Adjustment Model with Inventory 53
2.8 Price Adjustment with Inventory 54
2.9 Effects of the Changes in Demand, Supply and Inventory Coverage 55
2.10 Auctioneer vs Inventory Price Mechanism Compared 56
2.11 Auctioneer vs Inventory Price Behaviors 56
2.12 Historical Price Stability with Adjusted Supply Schedule (1) . . . 57
2.13 Historical Price Stability with Adjusted Supply Schedule (2) . . . 58
2.14 A Causal Loop of A Pure Exchange Economy 60
2.15 A Pure Exchange Economy Model 61
2.16 Tâtonnement Adjustment Process 61
2.17 Price Movement of Period 1, 2, 4 and Chaos 62
2.18 Chaotic Price for λ 62
2.19 Sensitive Dependence on Initial Conditions 63
2.20 Price Movement of Period 1, 2, 4 and Chaos Caused by Tastes . 64
2.21 Chaotic Price for α 64
2.22 Co-flows of Goods and Money 67

3.1 Stock-Flow Relation 75
3.2 Balance Sheet in [42] as a Collection of Stocks 77
3.3 Net Fixed Assets (Book Value) Relation 77
3.4 Income Statement as Stock-Flow Relation 78
3.5 Double Entry Rule of Bookkeeping as Debit and Credit 80
3.6 Double Entry Rule of Bookkeeping (1) 81
3.7 Double Entry Rule of Bookkeeping (2) 81
3.8 Double Entry Rule of Bookkeeping (3) 82
3.9 Double Entry Rule of Bookkeeping (4)) 82
3.10 Accounting System Dynamics Simplified 85
3.11 Inventories with Production 90
3.12 Double Transactions caused by Customer Order 94
3.13 Income Statement 97
3.14 Balance Sheet 98
3.15 Cash Flow Statement 99

3.16 List of Transaction Data 100
3.17 Ratio Analysis Diagram 102
3.18 Returns on Assets and Equity 103
3.19 Net Cash Flow and Net Income 104

4.1 Macroeconomic System Overview 110
4.2 Macroeconomic System Flow Chart 113
4.3 Cash Flow of Producers 114
4.4 A Macroeconomic System Flow Chart with Banks 115
4.5 A Macroeconomic System Flow Chart with Investment Institutions 116
4.6 Macroeconomic System Flow Chart of MuRatopian Economy . . 117
4.7 Causal loops of the Goodwin Model 120
4.8 The Goodwin Growth Cycle Model 120
4.9 Wage Rates and Output 122
4.10 Adjustment in Labor Market 122
4.11 Business Cycle 123
4.12 Ratio Elasticity of Desired Wage Rate 123
4.13 Phase Diagram of Labor-Employment Ratio and Workers' Share 124
4.14 A Monetary Goodwin Model 125
4.15 Business Cycle caused by A Monetary Constraint 127
4.16 Desired Investment and Borrowing 127
4.17 Output and Unemployment Rate caused by A Credit Crunch . . 128
4.18 Accumulating Debt caused by A Business Cycle and Credit Crunch 128
4.19 Balance Sheet of the Monetary Goodwin Model with Interest . . 130
4.20 Output and Unemployment with Interest Rate: 0 - 30 years . . . 131
4.21 Output and Unemployment with Interest Rate: 30 - 50 years . . 131
4.22 Increasing Bank Equity and Debt-GDP ratio: 30 - 50 years . . . 132
4.23 Desired Investment and Borrowing at a Prime Rate Spread=3% . 132
4.24 Breaking Phase Diagram of Labor-Employment Ratio and Workers' Share 133
4.25 Debt-GDP Ratio and Unemployment Rate: 20 - 50 years 134
4.26 Recovering Output with Interest Rate: 30 - 55 years 134
4.27 Recovering Unemployment with Interest Rate: 30 - 55 years . . . 135

5.1 Coflow of Money and Commodity 140
5.2 Base Money as Legal Tender 144
5.3 Issuance of Base Money Backed by Various Types of Assets . . . 144
5.4 Deposits as Functional-Money 145
5.5 Debt Money System 147
5.6 $M_0 + M_f = M_1$ in Japan (1980 - 2018) 151
5.7 $M_0 + M_f = M_1$ and $M_1 + M_T = M_3$ in Japan 151
5.8 Three Sectors for Money Stock 153
5.9 Flow Approach of Money Creation 155
5.10 Money Stock Definitions for Flow and Stock Approaches 159
5.11 Money Multiplier and Convertibility Coefficient in Japan 160
5.12 Stock Approach of Money Creation 163

5.13 Money Creation Model under Gold Standard: Flow Approach . . 168
5.14 Money Stock under Gold Standard 169
5.15 Currency Outstanding and Cash outside the Central Bank 171
5.16 Money Stock when Loan Adjustment Time triples. 172
5.17 Money Stock when Vault Cash Rate is 0.5. 173
5.18 Money Stock when Currency Ratio doubles at t = 8 174
5.19 100% Fractional Reserve at t=8 174
5.20 Money Stock, Assets, Equity and Debt 175
5.21 Money Creation Model under Gold Standard: Stock Approach . 176
5.22 Money Stock under Gold Standard: Stock Approach 177
5.23 Base Money, Deposits and Money Stock: 100% Reserve at t=30 . 178
5.24 Money Creation Model out of Discount Loans to Banks 181
5.25 Money Stock Creation out of Discount Loans to Banks 182
5.26 Assets, Equity and Debts 182
5.27 Money Creation Model out of Loan to Banks: Stock Approach . 183
5.28 Money Stock Creation out of Loans to Banks: Comparison . . . 184
5.29 A Complete Money Creation Model: Non-Financial Sector 185
5.30 Non-Financial Sector (Government) 186
5.31 A Complete Money Creation Model: Commercial Banks 186
5.32 A Complete Money Creation Model: Central Bank 187
5.33 Simulation of Government Securities (Debt) 188
5.34 Simulation of Open Market Purchase and Sale Operations 189
5.35 Open Market Operation with Currency Ratio Doubled 190
5.36 Assets, Equity and Debt of Non-Financial Sector (Public) 190
5.37 A Complete Money Creation Model: Stock Approach 191
5.38 Simulation of Open Market Operation 192
5.39 Behaviors of Base Money and Money Stock: Flow Approach . . . 194
5.40 Behaviors of Base Money and Money Stock: Stock Approach . . 194

6.1 Money Stock = Public Money + Debt Money 200
6.2 Debt Money = Total Debts 201
6.3 Money Stock = Debt Money = Total Debts = $M_0 + M_f$ 203
6.4 Correlation Coefficients of All Money Stocks and Debts 205
6.5 Money Stock $M_3 \simeq$ Total Domestic Debts (1980-2018) 206
6.6 Causes of Money Stock Destruction 209
6.7 Destruction of Money Stock Compared 210
6.8 Recessions and Open Market QE policy 211
6.9 Failure of QE policy 212
6.10 Business Cycle and Random Normal Distribution 213
6.11 Instability of Money Stock 214
6.12 From 100% Money Stock to Public Money Stock 215

7.1 Money and Interest under Gold Standard: Flow Approach 222
7.2 Money Stock and Equity under Gold Standard: Flow Approach . 223
7.3 Money and Interest under Gold Standard: Stock Approach . . . 224
7.4 Money Stock and Equity under Gold Standard: Stock Approach 225

7.5 Money Stock and Equity under Loans to Banks 225
7.6 Money Stock and Equity under Loans to Banks 226
7.7 Money Stock and Equity under Government Debt Compared . . 227
7.8 Money Stock and Equity under Government Debt 228
7.9 Money Stock and Equity Compared (Stock Approach) 229
7.10 Money Stock and Equity under Government Debt: Stock Approach 229
7.11 Open Market Purchase and Sale Operations: Flow Approach . . 230
7.12 Public and Government Equities under Open Market Operations 231
7.13 Banks and Central Bank Equities under Open Market Operations 231
7.14 Non-Fin. vs Fin. Equity 232
7.15 Base Money and Money Stock under 6 Phases: Stock Approach . 233
7.16 Equity Distribution of the Public, and Fin. vs Non-Fin. 233
7.17 Public Equity Compared 234
7.18 Equity Distribution under Public Money: Stock Approach 235
7.19 Financial (Interest) System of Deposits/ Debts 236

8.1 Macroeconomic System Overview 242
8.2 Causal loops of Neoclassical and Keynesian Models 244
8.3 Keynesian Comparative Static Determination of GDP 245
8.4 Keynesian SD Model of GDP 246
8.5 Keynesian SD Determination of GDP 247
8.6 Revised Keynesian SD Model of GDP 249
8.7 SD Determination of GDP 249
8.8 IS-LM Determination of GDP and Interest Rate 251
8.9 Interest Rate Adjustment Process 253
8.10 Transactions of Producers 255
8.11 Transactions of Consumer 256
8.12 Transactions of Government 259
8.13 Transactions of Banks 260
8.14 Full Capacity Production 261
8.15 Aggregate Demand Mostly Equilibria 262
8.16 Aggregate Demand Disequilibria 263
8.17 Effect of Fiscal Policy 264
8.18 Behaviors of Interest Rate Compared 265
8.19 Skyrocketing Government Debt 266
8.20 Effect of Monetary Policy 267
8.21 Price and Interest Rate Adjustment Processes 270
8.22 Flexible Price Equilibria 271
8.23 Growth, Price, Money Supply, Demand and Interest Rate 271
8.24 Aggregate Demand and Supply Curves 272
8.25 Flexible Price Disequilibria 273
8.26 Growth, Price, Money Supply, Demand and Interest Rate 273
8.27 Growth-dependent Money Supply and its Effect on Interest Rate 274
8.28 Growth-dependent Money Supply on GDP and Growth Rate . . 274
8.29 Growth-dependent Money Supply on IS-LM 275
8.30 Interest Rate and Price Adjustment Process Revisited 277

8.31 Disequilibria triggered by A Technological Progress 278
8.32 Business Cycles under Price Flexibility 279
8.33 Aggregate Demand and Supply Curves 280

9.1 Macroeconomic System Overview 288
9.2 Real Production of GDP 290
9.3 Interest Rate and Price Adjustments 293
9.4 Lending by the Central Bank and its Growth Rate 294
9.5 Transactions of Producers 297
9.6 Transactions of Consumer 298
9.7 Transactions of Government 299
9.8 Transactions of Banks 301
9.9 Transactions of Central Bank 303
9.10 Mostly Equilibrium States 304
9.11 Growth and Inflation Rates of Mostly Equilibrium States 304
9.12 Fixprice and Mostly Equilibrium States 305
9.13 Business Cycles by Inventory Coverage 305
9.14 Business Cycles by Elastic Price Fluctuation 306
9.15 Money Supply and Interest Rate by Credit Crunch 306
9.16 Economic Recession by Credit Crunch 307
9.17 Currency in Circulation and Deposits by Bank Run 307
9.18 Money Supply and Depression by Bank Run 308
9.19 Monetary Policy: Open Market Purchase and GDP 309
9.20 Fiscal Policy: Change in Income Tax Rate and Interest Rate . . 310
9.21 Accumulation of Government Debt 311
9.22 Government Debt Deduction 312
9.23 Effect of Government Debt Deduction 312
9.24 Price Flexibility, Business Cycles and Debt Reduction 313
9.25 Comparison of GDP paths 313

10.1 Macroeconomic System Overview 318
10.2 Real Production of GDP 322
10.3 Population and Labor Market 324
10.4 Interest Rate, Price and Wage Rate 326
10.5 Transactions of Producers 327
10.6 Transactions of Consumer 328
10.7 Transactions of Government 330
10.8 Transactions of Banks 332
10.9 Transactions of Central Bank 334
10.10 Mostly Equilibrium States 335
10.11 GDP Gap Ratio and Unemployment Rate of the Equilibrium States 335
10.12 Fixprice and Mostly Equilibrium States 336
10.13 Business Cycles caused by Inventory Coverage 336
10.14 Business Cycles caused by Elastic Price Fluctuation 337
10.15 Business Cycles caused by Cost-push Price 337
10.16 Wage, Inflation and Unemployment Rates and GDP Gap 338

10.17Okun's Law and Phillips Curve 338
10.18Money Supply and Interest Rate by Credit Crunch 339
10.19Economic Recessions caused by Credit Crunch 339
10.20Currency in Circulation and Deposits by Bank Run 340
10.21Money Supply and Depression by Bank Run 340
10.22Depression by Bank Run 341
10.23Monetary Policy of Open Market Purchase and GDP 342
10.24Fiscal Policy of a Change in Income Tax Rate and GDP 343
10.25Accumulation of Government Debt 343
10.26Government Debt Deduction 344
10.27Effect of Government Debt Deduction 345
10.28GDP Gap and Unemployment Rate under Price Flexibility . . . 345
10.29Comparison of GDP paths 346

11.1 Foreign Sector as a Mirror Image of Domestic Macroeconomy . . 352
11.2 Transactions of Producers 354
11.3 Transactions of Foreign Producers 355
11.4 Transactions of Consumers and Government 356
11.5 Transactions of Banks 358
11.6 Transactions of Foreign Banks 359
11.7 Transactions of the Central Bank 360
11.8 The Balance of Payments 361
11.9 A Simulation of Balance of Payments 362
11.10Normalized Demand Curve 362
11.11Trade Balance vs Foreign Exchange Rate 364
11.12Direct and Financial Investment Indices 366
11.13Net Capital Inflow vs Foreign Exchange Rate 367
11.14Determination of Foreign Exchange 369
11.15Causal Loop Diagram of the Foreign Exchange Dynamics 370
11.16Equilibrium State of Trade and Foreign Exchange Rate (S) . . . 370
11.17Foreign GDP Plunge and Restoring Trade Balance (S1) 371
11.18Foreign Inflation and Restoring Trade Balance (S2) 372
11.19Random Expectations and Foreign Investment (S3) 373
11.20Interest Plummet under Random Expectations (S4) 374
11.21Comparison of the Balance of Payments between S3 and S4 . . . 375
11.22Foreign GDP Plunge and Foreign Investment (S5) 375
11.23Official Intervention and Default (S6) 377
11.24Zero Interest Rate and Default (S7) 378
11.25No Official Intervention (S8) 379
11.26Missing Feedback Loops Added to the Foreign Exchange Dynamics380

12.1 Open Macroeconomic System Overview 384
12.2 Fixed Missing Loops in the Foreign Exchange Dynamics Model . 389
12.3 Population and Labor Force 390
12.4 GDP Determination 391
12.5 Interest Rate, Price and Wage Rate 392

12.6 Transactions of Producers . . . 393
12.7 Transactions of Consumers . . . 394
12.8 Transactions of Government . . . 395
12.9 Transactions of Banks . . . 396
12.10Transactions of Central Bank . . . 397
12.11Foreign Exchange Market . . . 398
12.12Balance of Payment . . . 399
12.13Simulation Panel of GDP . . . 400
12.14Simulation Panel of Trade and Investment Abroad . . . 401
12.15Mostly Equilibria under Trade and Capital Flows . . . 402
12.16Trade Balance and Balance of Payments . . . 403
12.17Interest Arbitrage and Financial Investment . . . 403
12.18Inventory Business Cycles under Trade and Capital Flow . . . 404
12.19Inventory Business Cycles Affecting Foreign Macroeconomy . . . 404
12.20Credit Crunch under Trade and Capital Flow . . . 405
12.21Credit Crunch Affecting Foreign Macroeconomy . . . 405

13.1 U.S. National Debt and its Forecast: 1970 - 2020 . . . 414
13.2 Impasses of Defaults, Financial Meltdown and Hyper-Inflation . . . 415
13.3 Transactions of Government . . . 425
13.4 Transactions of Banks . . . 426
13.5 Transactions of Central Bank . . . 428
13.6 Mostly Equilibrium States . . . 429
13.7 Lending by the Central Bank and its Growth Rate . . . 430
13.8 Accumulation of Government Debt and Debt-GDP Ratio . . . 431
13.9 Liquidation Policies: Spend Less and Tax More . . . 432
13.10Comparison of GDP paths . . . 433
13.11Transactions of Government . . . 435
13.12100% Required Reserve Ratios . . . 436
13.13Transactions of the Public Money Administration . . . 437
13.14Liquidation of Government Debt and Debt-GDP Ratio . . . 438
13.15Comparison of GDP and Growth Rates . . . 439
13.16Price Level and Inflation Rate . . . 439
13.17No Inflation under GDP Gap . . . 440
13.18Inflation under No GDP Gap . . . 440
13.19Business Cycles caused by Inflation under No GDP Gap . . . 440

14.1 Mostly Equilibrium States . . . 447
14.2 GDP Gap and Unemployment Rate of Mostly Equilibrium States 447
14.3 Lending by the Central Bank and its Growth Rate . . . 448
14.4 Accumulation of Government Debt and Debt-GDP Ratio . . . 449
14.5 Liquidation Policies: Spend Less and Tax More . . . 450
14.6 Recessions triggered by Debt Liquidation . . . 451
14.7 GDP Gap and Unemployment . . . 452
14.8 Wage Rate and Inflation . . . 452
14.9 Foreign Recessions Contagiously Triggered . . . 453

14.10Liquidation Traps of Debt 453
14.11Causal Loop Diagram of Liquidation Traps of Debt 454
14.12Transactions of Government 455
14.13100% Required Reserve Ratios 456
14.14Transactions of Public Money Administration (Central Bank) . . 457
14.15Liquidation of Government Debt and Debt-GDP Ratio 458
14.16No Recessions Triggered by A Public Money System 459
14.17GDP Gap and Unemployment 459
14.18Wage Rate and Inflation 459
14.19Foreign Recessions are Not Triggered 460
14.20Public Money Policies 461
14.21GDP Gap and Its Public Money Policy 462
14.22GDP Gap and Unemployment Recovered 462
14.23Price and Inflation Rate 463
14.24GDP Gap and Unemployment 463
14.25Business Cycles caused by Inflation under No GDP Gap 464

15.1 Transactions of Producers 471
15.2 Transactions of Consumers 472
15.3 Transactions of Banks 473
15.4 Keynesian GDP Determination 474
15.5 Determination of GDP and Price 475
15.6 Keynesian Determination of GDP 476
15.7 Monetary Constraint GDP 478
15.8 Credit Creation 479
15.9 Equilibrium GDP by Credit Creation(100%) 479
15.10Money Supply: M0, M1 and M2 481
15.11Changes in Money Supply and Net Interest Income of Bankers . 482
15.12Greed of Bankers 483
15.13Price Levels and Inflation Rates with Credit Overshooting 483
15.14Interest-Wage Ratio and Wage Distribution 484
15.15Reduction of M1 and Deflation by Credit Crunch 485
15.16Recession (GDP and Growth Rate) triggered by Credit Crunch . 485
15.17Causal Loop Diagram of Debt Money System 486
15.18Sensitivity of Credit Creation on Growth Rates 487
15.19Sensitivity of Credit Creation on Inflation Rates 487
15.20GDP under Debt vs Public Money System 489
15.21Money Supply and Inflation under Debt vs Public Money 490
15.22Interest Income and Wage Distribution under Debt vs Public Money490
15.23Causal Loop Diagram of Public Money System 491
15.24Debt-vs-Public System Sensitivity: Inflation Rates 492
15.25Debt-vs-Public System Sensitivity: Wage Distribution 492
15.26Debt-vs-Public System Sensitivity: GDP 493

16.1 Inequality under Debt Money System 502
16.2 Re-unified Co-Workers 506

17.1 (0) Initial Base Money 516
17.2 Definition of Money Supply 517
17.3 Bubbles and Recessions under the Debt Money System 519
17.4 (1) Fractional Reserve Banking System 521
17.5 (2) Making Bubbles 522
17.6 (3) Bubble Burst and Bank-runs 523
17.7 (4) Credit Crunch → Depressions 524
17.8 (5) Issuing Securities → Restore Money Supply 525
17.9 (6) Bailout → Accumulated Debt 527
17.10(7) Collapse of Securities 528
17.11(8) Financial Quantitative Easing (QE) 529
17.12Monetary Instability under the Debt Money System 531
17.13Parameters under the Debt Money System 531
17.14Definition of Money Multiplier 532
17.15Instability of Money Multiplier 533
17.16(T1) Conversion to the Public Money 537
17.17(T2) Securities as Reserves Collateral 538
17.18(T3) Public Money Issued 539
17.19(T4) Debt Liquidation: Money Supply Unchanged 540
17.20(T5) Public Money Converted to Time Deposits 541
17.21(T6) Public Money Added into Circulation for Welfare and Growth 542
17.22From Debt Money to Public Money System 544
17.23Money Multiplier from Debt Money to Public Money System . . 544
17.24Monetary Stabilization under the Public Money System 545

18.1 Proposals for Public Money System and Bitcoin in the Year 2008 551
18.2 Income Inequality between Financiers and Non-financiers 558
18.3 Overview of Payment System under Public and Debt Money . . 560
18.4 Overview of Payment Methods under Debt Money System 561
18.5 Payment System ① with Cash: Peer-to-Peer 562
18.6 Payment System ② with Electronic Cash 563
18.7 Payment System ③ with Bank Deposits 564
18.8 Payment System ④ with Multiple Bank Deposits 565
18.9 Payment System ⑤ through Nonbank Intermediaries (Credit Cards) 566
18.10Payment System ⑥ through Nonbank Intermediaries and Multiple Banks 567
18.11From Debt Money to Public Money System 569
18.12Organizational Structure of the Public Money Administration (Japan) 571
18.13Overview of Debt Money and Bitcoin Payments 576
18.14Payment System with Bitcoin: Peer-to-Peer 577
18.15Stock-Flow Presentation of Transaction Ledger 578
18.16Collapsing Debt Money Systems 580
18.17Unified System Design of Electronic Public Money 582
18.18A Network within a Single EPM Region 594
18.19A Network of Worldwide EPM systems 595

List of Tables

1.1 Classification of Stock 6
1.2 Linear Flow Calculation of $x(10)$ for dt=1 and 0.5 13
1.3 Discrete Approximation for $x(10)$ 13
1.4 Discrete Approximation for $x(6)$ 15
1.5 2nd- and 4th-Order Runge-Kutta Method ($dt = 1$) 15
1.6 Discrete Approximation 18
1.7 Equations of the First-Order Growth Model 23
1.8 Same Number of Calculation 42

2.1 Demand and Supply Schedules in [86] 47
2.2 Effect of Inventory Ratio on Price 53

3.1 Balance Sheet in [42] 76
3.2 Income Statement in [42] 78
3.3 Cash Flow Statement in [42] 79
3.4 All Transaction Data 87
3.5 Inventory Valuation Worksheet for Transaction 18 92
3.6 Balance Sheet Table 101

5.1 Journal Entries of Transaction with Cash 141
5.2 Public Money vs Debt Money 143
5.3 Journal Entries of Transaction with Deposits 146
5.4 Money Stock & its Composition in Japan (2018) 149
5.5 Classification of Money (Front & Back) 149
5.6 Journal Entries of Flow Approach in (2) and (3) 160
5.7 Transactions of Non-Banking Sectors: Flow Approach 161
5.8 Journal Entries of Stock Approach in (2) and (3) 164
5.9 Transactions of Non-Banking Sector: Stock Approach 165

6.1 From Debt Money System to Public Money System 216

7.1 Summary Table of Open Market Purchase: Stock Approach . . . 233

13.1 Public Debt-GDP Ratio(%) of OECD Countries in 2010 413

16.1 Public Money vs Debt Money System Structures 496
16.2 Public Money vs Debt Money System Behaviors 499
16.3 The Green Village(MuRatopia) Economic System of Public Money 509

18.1 Public Money vs Debt Money 552
18.2 System Structures of Public Money and Debt Money 555
18.3 System Behaviors of Public Money and Debt Money 556
18.4 Classification of Blockchain-based Public and Debt Money 585
18.5 Ranking By Market Capitalization 586