1

**PM-1 3½"x4" PHOTOGRAPHIC MICROCOPY TARGET
NBS 1010a ANSI/ISO #2 EQUIVALENT**

PRECISIONSM RESOLUTION TARGETS

National Library
of Canada

Acquisitions and
Bibliographic Services Branch

395 Wellington Street
Ottawa, Ontario
K1A 0N4

Bibliothèque nationale
du Canada

Direction des acquisitions et
des services bibliographiques

395, rue Wellington
Ottawa (Ontario)
K1A 0N4

Titre de votre référence

Numéro de votre référence

NOTICE

The quality of this microform is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree.

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us an inferior photocopy.

Reproduction in full or in part of this microform is governed by the Canadian Copyright Act, R.S.C. 1970, c. C-30, and subsequent amendments.

AVIS

La qualité de cette microforme dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il manque des pages, veuillez communiquer avec l'université qui a conféré le grade.

La qualité d'impression de certaines pages peut laisser à désirer, surtout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de qualité inférieure.

La reproduction, même partielle, de cette microforme est soumise à la Loi canadienne sur le droit d'auteur, SRC 1970, c. C-30, et ses amendements subséquents.

**THE INTEGRATION
OF INTERNATIONAL EQUITY MARKETS**

by

Amanda X.Q. Lu, B.A., M.A.

A thesis submitted to
the Faculty of Graduate Studies and Research
in partial fulfilment of
the requirements for the degree of

Doctor of Philosophy

Department of Economics
Carleton University
Ottawa, Ontario

September, 1995

@ copyright

1995, Amanda X.Q. Lu

National Library
of Canada

Acquisitions and
Bibliographic Services Branch

395 Wellington Street
Ottawa, Ontario
K1A 0N4

Bibliothèque nationale
du Canada

Direction des acquisitions et
des services bibliographiques

395, rue Wellington
Ottawa (Ontario)
K1A 0N4

Your file / Votre référence

Our file / Notre référence

The author has granted an irrevocable non-exclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of his/her thesis by any means and in any form or format, making this thesis available to interested persons.

L'auteur a accordé une licence irrévocable et non exclusive permettant à la Bibliothèque nationale du Canada de reproduire, prêter, distribuer ou vendre des copies de sa thèse de quelque manière et sous quelque forme que ce soit pour mettre des exemplaires de cette thèse à la disposition des personnes intéressées.

The author retains ownership of the copyright in his/her thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without his/her permission.

L'auteur conserve la propriété du droit d'auteur qui protège sa thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

ISBN 0-612-08847-2

Canada

Name ALLANNA X. G. LU

Dissertation Abstracts International is arranged by broad, general subject categories. Please select the one subject which most nearly describes the content of your dissertation. Enter the corresponding four-digit code in the spaces provided.

EDUCATION

SUBJECT TERM

0508

SUBJECT CODE

U·M·I

Subject Categories

THE HUMANITIES AND SOCIAL SCIENCES

COMMUNICATIONS AND THE ARTS

Architecture 0729
Art History 0317
Cinema 0900
Dance 0378
Fine Arts 0357
Information Science 0723
Journalism 0391
Library Science 0399
Mass Communications 0708
Music 0413
Speech Communication 0459
Theater 0465

EDUCATION

General 0515
Administration 0514
Adult and Continuing 0516
Agricultural 0517
Art 0273
Bilingual and Multicultural 0282
Business 0688
Community College 0275
Curriculum and Instruction 0727
Early Childhood 0518
Elementary 0524
Finance 0277
Guidance and Counseling 0519
Health 0680
Higher 0745
History of 0520
Home Economics 0278
Industrial 0521
Language and Literature 0274
Mathematics 0280
Music 0522
Philosophy of 0998
Physical 0523

Psychology 0525
Reading 0535
Religious 0527
Sciences 0714
Secondary 0533
Social Sciences 0534
Sociology of 0340
Special 0529
Teacher Training 0530
Technology 0710
Tests and Measurements 0288
Vocational 0747

LANGUAGE, LITERATURE AND LINGUISTICS

Language
General 0679
Ancient 0289
Linguistics 0290
Modern 0291
Literature
General 0401
Classical 0294
Comparative 0295
Medieval 0297
Modern 0298
African 0316
American 0591
Asian 0305
Canadian (English) 0352
Canadian (French) 0355
English 0593
Germanic 0311
Latin American 0312
Middle Eastern 0315
Romance 0313
Slavic and East European 0314

PHILOSOPHY, RELIGION AND THEOLOGY

Philosophy 0422
Religion
General 0318
Biblical Studies 0321
Clergy 0319
History of 0320
Philosophy of 0322
Theology 0469

SOCIAL SCIENCES

American Studies 0323
Anthropology
Archaeology 0324
Cultural 0326
Physical 0327
Business Administration
General 0310
Accounting 0272
Banking 0770
Management 0454
Marketing 0338
Canadian Studies 0385
Economics
General 0501
Agricultural 0503
Commerce Business 0505
Finance 0508
History 0509
Labor 0510
Theory 0511
Folklore 0358
Geography 0366
Gerontology 0351
History
General 0578

Ancient 0579
Medieval 0581
Modern 0582
Black 0328
African 0331
Asia, Australia and Oceania 0332
Canadian 0334
European 0335
Latin American 0336
Middle Eastern 0333
United States 0337
History of Science 0585
Law 0398
Political Science
General 0615
International Law and Relations 0616
Public Administration 0617
Recreation 0814
Social Work 0452
Sociology
General 0626
Criminology and Penology 0627
Demography 0938
Ethnic and Racial Studies 0631
Individual and Family Studies 0628
Industrial and Labor Relations 0629
Public and Social Welfare 0630
Social Structure and Development 0700
Theory and Methods 0344
Transportation 0709
Urban and Regional Planning 0999
Women's Studies 0453

THE SCIENCES AND ENGINEERING

BIOLOGICAL SCIENCES

Agriculture
General 0473
Agronomy 0285
Animal Culture and Nutrition 0475
Animal Pathology 0476
Food Science and Technology 0359
Forestry and Wildlife 0478
Plant Culture 0479
Plant Pathology 0480
Plant Physiology 0817
Range Management 0777
Wood Technology 0746
Biology
General 0306
Anatomy 0287
Biostatistics 0308
Botany 0309
Cell 0379
Ecology 0329
Entomology 0353
Genetics 0369
Immunology 0793
Microbiology 0410
Molecular 0307
Neuroscience 0317
Oceanography 0416
Physiology 0433
Radiation 0821
Veterinary Science 0778
Zoology 0472
Biophysics
General 0786
Medical 0760

EARTH SCIENCES

Biogeochemistry 0425
Geochemistry 0996

Geodesy 0370
Geology 0372
Geophysics 0373
Hydrology 0388
Mineralogy 0411
Paleobotany 0345
Paleoecology 0426
Paleontology 0418
Paleozoology 0985
Palynology 0427
Physical Geography 0368
Physical Oceanography 0415

HEALTH AND ENVIRONMENTAL SCIENCES

Environmental Sciences 0768
Health Sciences
General 0566
Audiology 0300
Chemotherapy 0992
Dentistry 0567
Education 0350
Hospital Management 0769
Human Development 0758
Immunology 0982
Medicine and Surgery 0564
Mental Health 0347
Nursing 0569
Nutrition 0570
Obstetrics and Gynecology 0380
Occupational Health and Therapy 0354
Ophthalmology 0381
Pathology 0571
Pharmacology 0419
Pharmacy 0572
Physical Therapy 0382
Public Health 0573
Radiology 0574
Recreation 0575

Speech Pathology 0460
Toxicology 0383
Home Economics 0386

PHYSICAL SCIENCES

Pure Sciences
Chemistry
General 0485
Agricultural 0749
Analytical 0486
Biochemistry 0487
Inorganic 0488
Nuclear 0738
Organic 0490
Pharmaceutical 0491
Physical 0494
Polymer 0495
Radiation 0754
Mathematics 0405
Physics
General 0605
Acoustics 0986
Astronomy and Astrophysics 0606
Atmospheric Science 0608
Atomic 0748
Electronics and Electricity 0607
Elementary Particles and High Energy 0798
Fluid and Plasma 0759
Molecular 0609
Nuclear 0610
Optics 0752
Radiation 0756
Solid State 0611
Statistics 0463
Applied Sciences
Applied Mechanics 0346
Computer Science 0984

Engineering
General 0537
Aerospace 0538
Agricultural 0539
Automotive 0540
Biomedical 0541
Chemical 0542
Civil 0543
Electronics and Electrical 0544
Heat and Thermodynamics 0348
Hydraulic 0545
Industrial 0546
Marine 0547
Materials Science 0794
Mechanical 0548
Metallurgy 0743
Mining 0551
Nuclear 0552
Packaging 0549
Petroleum 0765
Sanitary and Municipal 0554
System Science 0790
Geotechnology 0428
Operations Research 0796
Plastics Technology 0795
Textile Technology 0994

PSYCHOLOGY

General 0621
Behavioral 0384
Clinical 0622
Developmental 0620
Experimental 0623
Industrial 0624
Personality 0625
Physiological 0989
Psychobiology 0349
Psychometrics 0632
Social 0451

The undersigned hereby recommend to
the Faculty of Graduate Studies and Research
acceptance of the thesis,

"THE INTEGRATION OF INTERNATIONAL EQUITY MARKETS"

submitted by

Xiao Qiang LU, B.A., M.A.

in partial fulfilment of the requirements
for the degree of Doctor of Philosophy

Chair, Department of Economics

Thesis Supervisor

External Examiner

Carleton University
September 1995

To Allan and my parents, with love

Abstract

Although it is generally believed that international financial markets have become increasingly integrated, the available empirical evidence suggests that short-run discrepancies among *ex post* equity returns of different economies have persisted. This dissertation theoretically and empirically explores the integration of international equity markets and macroeconomic mechanisms that produce the observed short-run deviations and long-run correlations among equity returns across markets.

This dissertation develops a symmetric-two-country macroeconomic model with optimizing agents to characterize the dynamics of world equity prices in response to fundamental innovations. Using a technique that decomposes the simultaneous differential-equation system of the model into the world average and relative fundamentals, the model formalizes theoretically the time-series concept of cointegrating relationship between two equity markets, and the causes of short-run deviations from such a relationship. The model demonstrates that short-run discrepancies between equity returns arise because macroeconomic innovations in one economy may produce non-contemporaneous, or even opposite effects, on the fundamentals of the other economy. However, the discrepancies will be eliminated over time by repercussion effects associated with the innovations and international portfolio adjustments. Equity returns across markets are therefore equalized on average over the long run.

Time-series analyses are then employed to investigate the correlations among the U.S., U.K., Canadian and Japanese equity markets during 1985-93, using daily data. Specifically, an error-correction representation of a cointegrated vector autoregression system is estimated to characterize the dynamic behavior of these markets in response to innovations in each other. An event study is then conducted to examine the impacts of economic fundamentals on these markets.

Evidence of cointegration is found for some pairs of equity markets during the nine-year period. Contemporaneous correlations among these markets are less than perfect. However, the estimates suggest considerable multi-market interactions and persistent effects of variations in one market on another. Market responses to the previous deviations from their respective equilibrium price differentials are generally insignificant, which indicates partial error correction. Innovations in the U.S. fundamentals generally induce worldwide market reactions in the predicted directions.

Acknowledgments

I am immensely indebted to many people in the writing of this dissertation. First and foremost, I am extremely grateful to Professor Lawrence L. Schembri, my supervisor, for holding the torch high when I was probing in the dark tunnel of research. This dissertation would not be possible had I not had his continuous guidance, encouragement and thought-provoking comments.

An immense debt goes without saying to all professors who have taught me, and economists whose contributions to the subject lay the basis for this research. In the writing of this dissertation, I have had the benefit of valuable comments and suggestions from (in alphabetical order) Richard Brecher, Ehsan Choudhri, Michel Demers, Stephen Ferris, Soo Bin Park, Andre Plourde, Aileen Thompson and seminar participants at Carleton University and the 1994 and 1995 annual conferences of the Canadian Economics Association.

I am also grateful to the following friends for their generous help: Jim Cameron and Sergei Sawchyn for editing and proofreading some chapters, Xin He for mathematical advice, Rosa Kwang, Qin Lu and Rodney Schmidt for providing data.

Last but not the least, I want to express my deepest thanks to Allan and my parents. Without their selfless support and constant encouragement, writing this dissertation would have been an extremely difficult process.

Finally, all remaining errors in this dissertation are mine.

Table of Contents

	Page
Abstract	iv
Acknowledgments	v
Table of Contents	vi
List of Tables	viii
List of Figures	ix
CHAPTER I: Introduction	1
1. Introduction and Motivation	2
2. Outline	10
CHAPTER II: A Review of Empirical and Theoretical Literature	12
1. Introduction	13
2. The International Mobility of Capital	14
3. Empirical Studies on the Integration of International Equity Markets	23
4. Economic Fundamentals and the Integration of International Equity Markets	40
5. Concluding Remarks	55
CHAPTER III: A Two-Country Theoretical Model	59
1. Introduction	60
2. Basic Assumptions	61
3. Production of Traded and Nontraded Goods	65
4. Asset Market and Capital Investment	67
5. Households	76
6. Government Expenditures	79
7. Equilibria of Domestic and World Goods Markets	80
8. Solution of the Model	83
9. Concluding Remarks	107
CHAPTER IV: Effects of Fundamental Innovations on World Equity Markets	108
1. Introduction	109
2. Effects of Fiscal Expansions on World Equity Markets	110
3. Effects of A Domestic Corporate Tax Reduction on World	

Equity Markets	129
4. Effects of Changes in Real Interest Rates on World Equity Markets	137
5. Concluding Remarks	141
CHAPTER V: An Empirical Investigation of the Integration of International Equity Markets	143
1. Introduction	144
2. Stylized Facts of World Equity Markets	147
3. World Effects of Equity Market Innovations: The VECM Estimations	166
4. Effects of Economic Innovations on World Equity Markets: An Event Study	186
5. Concluding Remarks	209
CHAPTER VI: Conclusions	211
1. Summary and Conclusions	212
2. Potential Extensions	216
Appendix A: Steady State	219
Appendix B: Laplace Transforms: An Application	222
REFERENCES	228

List of Tables

Table Description	Page
5.1 Statistical Characteristics of Equity Market Daily Changes, (in Local Currencies), 1/1985-12/1993	152
5.2 Monthly Changes in Equity Price Indexes, 1/1985-12/1993	157
5.3 Statistical Characteristics of Equity Market Daily Changes, (in U.S. Dollars), 1/1/1985-12/31/1993	160
5.4 Test Statistics for Units Root in Equity Price Indexes, 1/1/1985-12/1/1993	165
5.5 Test Statistics for Cointegration between Equity Price Indexes, 1/1/1985-12/31/1993	165
5.6 Estimates of Four VECMs Using Daily Returns	177
5.7 Correlation Coefficient Matrices of Residual Returns	181
5.8 Equity Market Variance Decompositions, 1/1/1985-12/31/1993	183
5.9 Impulse Responses to Unit Shocks in Individual markets, 1/1/1985-12/31/1993	185
5.10 List of Events	189
5.11 The Estimated Impacts of Seven Events on Equity Markets, Equation (5.14)	204
5.12 The Estimated Impacts of Seven Events on Equity Returns, Equation (5.17)	207

List of Figures

Figure	Description	Page
3.1.	World Capital Accumulation and Equity Market Equilibrium	97
3.2.	Equilibrium of the World Difference System	106
4.1.	World Response to an Unanticipated Symmetric Permanent Fiscal Expansion	114
4.2.	World Response to an Unanticipated Symmetric Temporary Fiscal Expansion	117
4.3.	World Response to an Anticipated Symmetric Permanent Fiscal Expansion	120
4.4.	World Response to an Anticipated or an Unanticipated Domestic Fiscal Expansion	125
4.5.	Effects of an Anticipated or an Unanticipated Domestic Tax Cut on the World Average System	132
4.6.	Effects of an Anticipated or an Unanticipated Domestic Tax Cut on the World Difference System	134
5.1.	Monthly Average Equity Price Indexes, in Local Currencies, 1/1985-12/1993	151
5.2.	Monthly Changes in Equity Price Indexes, in Local Currencies 1/1985-12/1993	153
5.3.	Monthly Average Equity Price Indexes, in U.S. Dollars 1/1985-12/1993	157
5.4.	Monthly Changes in Equity Price Indexes, in U.S. Dollars 1/1985-12/1993	158

CHAPTER I

INTRODUCTION

Beginning with Mundell-Fleming's integration of asset markets and capital mobility into open economy macroeconomic models, studies of international economics have often been based on the assumption that capital is perfectly mobile across borders and financial markets. This theoretical assumption greatly simplifies model building. More significantly, it allows macroeconomics to encompass the international dimension of many economic issues, including the conduct of monetary and fiscal policies, foreign exchange market intervention policy, global repercussions of economic activities and finally, the integration of international financial markets, which is the particular subject of this dissertation.

Although controversial, the concept of perfect international capital mobility has been widely investigated through, broadly speaking, two approaches that are distinguished by the way they define capital mobility. For the convenience of analysis, the first of these approaches may be called the *direct* approach. It proceeds by directly examining the magnitude of capital flows. Studies taking this approach originate from a 1980 paper by M. Feldstein and C. Horioka in which they argue that an indicator of the degree of capital mobility is the correlation of an economy's domestic savings and investment. The other approach, called here the *indirect* approach, compares rates of returns on similar assets traded in different markets. Studies using this approach are developed on the basis of interest parity conditions. Using such an indirect approach, this dissertation will both theoretically and empirically investigate the integration of a subset of international financial markets, namely equity markets.

To start, this introductory chapter relates the motivation of the current dissertation to the important concept of international capital mobility. Further, this chapter outlines the issues concerning the integration of international equity markets, which are to be addressed

in the dissertation.¹

1. Introduction and Motivation

If capital is internationally mobile, funds will move to markets where expected rates of returns on similar assets are higher. Such movement continues until expected rates of returns on financial assets traded in different national markets are equalized when measured in the same currency if the financial assets share the same risk characteristics, such as exchange risks, the risk of capital controls and government regulations, defaults risks, the length of maturity and the degree of liquidity. Consequently, world financial markets are integrated into one by international arbitrage.

According to the definition suggested by Booth et al. of the Bank of Canada (1985), the term "international capital mobility" implies that comparable domestic and foreign assets are close to perfect substitutes for each other when covered in foreign exchange markets, and there is no premium for differential political risk. This definition can be summarized by the covered interest parity condition:

$$i = i^* + fd.$$

The condition asserts that the interest rate differential between domestic and foreign economies, $i - i^*$, equals the forward premium, fd , on the domestic currency so that comparable

¹The word "integration" is sometimes used to describe the dynamic behavior of a time series. Its econometric implication to the subject matter of this dissertation will be discussed in Chapter V. However, throughout this dissertation, "integration" is used as a non-econometric term. It means that world financial markets are linked together by international arbitrage that leads to the equalization of expected rates of returns on internationally comparable assets.

financial assets of the two economies yield the same rate of return if transaction costs are zero. The covered interest parity condition is essentially a statement of the law of one price on international bond and money markets.

A stronger definition for capital mobility requires that markets pay no premium for exchange rate risk on internationally comparable assets. This situation holds when the risk premium attached to the acquisition of foreign assets is very small so that the forward premium, f_d , equals the expected rate of depreciation. This definition may be represented by the uncovered interest parity condition.

$$i = i^* + f_d,$$

where f_d is the expected rate of depreciation. Uncovered interest parity requires that interest rate differentials between domestic and comparable foreign assets uncovered in foreign exchange markets equal the expected rate of depreciation given zero transaction costs.

The notion of international financial integration has inspired considerable research interest because it is central to both the theory of international economics and the implementation of macroeconomic policies. Financial integration increases the economic interdependence between nations. As a result, the policy autonomy of an economy would be greatly reduced. For instance, for instance, if international financial markets are perfectly integrated, in most economies that are not large enough to influence the world interest rate, domestic monetary and fiscal policies cannot ultimately affect the real return on domestic capital. Nor can domestic capital formation be necessarily influenced by policies that alter domestic savings. Also, given a flexible exchange rate regime, an expansionary fiscal policy,

for example, raises domestic interest rates, which will crowd out domestic exports because of the appreciating effect of the higher domestic interest rate on the exchange rate. All these consequences indicate that there is much less room for policy intervention when international financial markets are perfectly integrated.

Besides, with perfect international financial integration, fundamentals that influence the financial market of a major world economy will concern not only investors who have invested in that economy, but also investors in other markets because innovations in the fundamentals of that economy may be transferred to other financial markets through various channels.

Another reason for the considerable research interest in the subject is that empirical evidence has not strongly supported the notion of international financial integration. Interest rates are generally found to have failed to converge internationally. Also, in world equity markets, persistent differences, sometimes substantial differences, among *ex post* equity returns have been detected. These differences do not appear to be systematically offset by exchange rate movements. Correlations among world equity markets have often been neither contemporaneous nor as strong and as stable on a daily basis as suggested by the assumption of perfect integration.

In a sense, this inconsistency between the theoretical assumption of complete arbitrage and reality arises inevitably because the perfect integration is in many ways a simplified concept of equilibrium. To start with, this assumption has ignored certain real-world complications, such as transaction costs, financial market imperfections, barriers to capital movements across economies, different tax treatments to domestic and foreign capital, and

more. These complications can make comparable assets imperfect substitutes.

Moreover, many unpredictable economic or political factors can create substantial discrepancies between the expected and the actual rates of returns on financial assets. Therefore, empirical evidence based on *ex post* data can only be suggestive.

Nevertheless, the assumption should produce a reasonable approximation of reality if equalization holds on average over time. This is possible if differences among prices of comparable assets are linear and constant and divergences from such a linear relationship are proved to be stochastically bounded and diminishing over time. This long-run equilibrium relationship is referred to in the time series studies as a cointegrating relationship.

Given the above arguments, this dissertation sets out to consider international financial integration, particularly the integration of international equity markets. There are three primary objectives to this dissertation. First, it will explore theoretically the nature of the integration of international equity markets. Mechanisms that govern this integration will be investigated by formalizing fundamentals underlying the long-run equilibrium relationships between national equity markets. Second, there will be efforts to reconcile the inconsistency between the theoretical assumption of financial integration and the empirical regularities of world equity markets. Short-run deviations of equity market movements from their long-run equilibrium relationship will be examined to identify transmission mechanisms of economic innovations across equity markets. Finally, the implications of the theoretical model will be tested to determine if they are consistent with the data.

To characterize theoretically empirical regularities of international equity markets poses several difficulties. First, it is necessary to develop a theoretical framework capable of

providing a general macroeconomic setting in which structural relationships among underlying variables can reflect the precise nature of equity markets.

Second, a two-country or multi-country model offers a better approach than a small-open economy model to investigate theoretically the integration of international equity markets. However, it is difficult to construct such a model because it must encompass simultaneous equilibrium conditions in more than one equity market.

Third, it is almost impossible for a theoretical model to capture all the fundamentals that would potentially influence equity returns. Therefore, it is unavoidable that a model can provide only a limited scope for dealing with the subject matter.

Last but not the least, the utmost goal of any theoretical economic model is to provide economic explanations of reality. To determine whether these explanations are consistent with experience, predictions generated by a theoretical model must be subject to empirical tests.

In order to deal with the first three difficulties, a two-country theoretical model is developed in this dissertation that incorporates optimal investment decisions and fundamental determinants for equity returns into an otherwise conventional two-country open economy macroeconomic model. The model is constructed on, among many underlying assumptions, the assumption of complete arbitrage among comparable financial assets across markets. Besides the fact that this assumption greatly simplifies model building, another reason for basing a model on this assumption is to see whether solutions and analytical results produced from such a model may lead to an outcome of less-than-perfect correlations among equity markets. Analytical results achieved with the model indicate that factors other than transaction

costs, barriers to capital movement, unforeseen exchange rate fluctuations may be causing less-than-perfect correlations among equity markets, at least in the short run. Such factors include the lagged response of one economy to an economic innovation in another economy, as well as the opposite effects economic innovations may produce on different national equity markets.

The theoretical model intends to extend the existing literature into several directions. First, the two-symmetric-open-economy model constructed in this dissertation is based on Murphy's new classical model for an optimizing small-open-economy (1989). In Murphy's model, optimizing investment decisions made by firms determine the market value of equity claims. Changes in endogenous variables that affect expected returns on capital induce adjustments in the equity price and the real exchange rate of the small open economy. Murphy's analysis treats the rest of the world as exogenous and thus ignores repercussion effects. However, repercussion effects are important in assessing the degree of interdependence among international financial markets. To reflect repercussion effects, the two-country model developed for this dissertation endogenizes the rest of the world. Thus, the interdependence between two economies in general, and between their equity markets in particular, can be directly analyzed in the model.

Secondly, transmission mechanisms of economic innovations are commonly analyzed in conventional two-open-economy macroeconomic models, such as those of Turnovsky (1986a), Bhandari and Genberg (1989) and Ambler (1989). Unlike those, the model in this dissertation synthesizes optimal investment decisions and equity markets with the conventional macroeconomic setting. This is to ensure that the structural relationships among

underlying economic variables derived from the model and the behavior of international equity markets formalized by the model are consistent with sound microeconomic foundations. In the model, fundamental determinants of expected equity returns of both economies are affected by macroeconomic policies of either or both economies, such as changes in government expenditures, tax rates and real interest rates. This process in turn influences the dynamics of equity prices, capital stocks and the real exchange rate of the two economies.

Thirdly, besides Turnovsky (1986a), Bhandari and Genberg (1989) and Ambler (1989), the model adds another application, but in the context of world equity markets, of a technique introduced by Aoki (1981). The technique decomposes a two-country macroeconomic model into two subsystems, each consisting of the average or the relative corresponding variables of the two economies. It is particularly appealing to use this technique for the purpose of this dissertation because the modeling of short-run and long-run movements in equity price differentials provides a theoretical formalization of the behavior of cointegrating equity markets.

To meet the last challenge to modeling international equity markets, comovements among the equity markets of the United States, the United Kingdom, Canada and Japan during 1985-1993 are examined to test empirically some of the analytical results and predictions produced by the theoretical model developed in this thesis. Evidence of cointegration is found for some markets during the nine-year period.

The study then adopts an error-correction representation for the cointegrated vector autoregression system (VECM) in which the dynamic multi-equity-market interactions to innovations in each other can be examined. The error-correction terms reflect the extent of

equity market adjustments in the current period to their deviations in the previous period from the long-run equilibrium. Results obtained from the VECM demonstrate significant correlations among the markets examined and persistent effects of innovations. The estimated coefficients for the error-correction terms provide empirical evidence for the dynamic adjustments of world equity price differentials discussed in the theoretical model.

Although the VECM approach characterizes many aspects of correlations among world equity markets, it cannot explain the structural relationship between underlying economic fundamentals and world equity market comovements. To fill this void and to test some predictions from the theoretical model, an event study is conducted to examine correlations among world equity returns in response to some specific economic events. The impacts of these events on individual equity markets are measured by coefficients of event-window dummy variables. In most cases, the economic events studied affect different equity markets in predicted directions. The events occurred in the United States are found to have significant effect on the four markets as a whole.

2. The Outline

This dissertation is organized into six chapters. Chapter II reviews both the theoretical and the empirical literature of international financial integration. It starts with the issue of international mobility of capital and delineates various approaches suggested by economists in recent years to search for the truth. The focus of the review then narrows from the integration of international financial markets in general to the integration of international equity markets in particular. Basic models and various developments in empirical studies on

the subject are examined, and the findings of these studies are summarized.

To deal with the issues addressed in the first two chapters, Chapter III develops an optimizing symmetric two-economy model that includes equity markets and investment decisions. The behavior of the model is depicted by a five-differential-equation system, which is then solved to provide a macroeconomic setting to analyze the effects of economic innovations on equity markets, investments, and the real exchange rate of the two economies.

Chapter IV studies and compares different responses of world equity markets to economic innovations in various situations. It identifies different patterns of joint reactions of domestic and foreign equity markets to an anticipated or an unanticipated, a permanent or a transitory, a symmetric or an asymmetric policy innovation. The analyses focus on searching for economic intuitions to the inconsistency between the assumption of perfect integration and the empirical regularities.

In Chapter V, implications of the theoretical model are empirically examined. The empirical study investigates through the VECM approach and an event-study the correlations among the U.S., U.K. Japanese and Canadian equity markets from January 1, 1985 to December 31, 1993.

Chapter VI summarizes all the important results, both theoretical and empirical, and discusses possible extensions to this research.

CHAPTER II

A REVIEW OF

EMPIRICAL AND THEORETICAL LITERATURE

1. Introduction

The increasing integration of international financial markets has been one of the most investigated and debated economic phenomenon of recent decades, especially after the world equity market crash in 1987. The complicated nature of global financial interdependence and its important implications for the implementation of national monetary, fiscal and foreign exchange intervention policies, investment, savings, trade, and fundamental determinations of the national financial market equilibrium, have inspired a considerable number of studies.

The primary issues these studies consider are: (1) To what degree are world financial markets correlated? (2) What conditions and mechanisms govern this correlation? (3) How can one model interdependent financial markets? The aim of this chapter is to put many diverse views on these issues into perspective and to note methodological developments in the research process.

In recent decades, a number of economists have contributed many important insights to our understanding of international financial integration. So many that it is impossible for this literature review to be comprehensive. Given time and space constraints, this review will discuss only the more recent developments in the literature and those that are particularly pertinent to the subject of the current dissertation. Besides, this review will avoid a fragmented approach and seek to provide a clear road map which readers can more easily follow through the growing and complex field of international financial integration.

The review starts in Section 2 with a discussion of two important approaches in investigating international capital mobility. The two approaches differ in the way they define international capital mobility, an issue essential to the evolution of studies of international

financial integration.

The focus of the review will then be narrowed to studies of the integration of international equity markets, a subset of international financial markets. In Section 3, various recent developments associated with empirical studies in the area will be discussed. Using different methods, these empirical studies have documented the main stylized facts of international equity markets. In Section 4, the review will focus on empirical and theoretical studies that explain and formalize macroeconomic mechanisms that bring about financial integration. Section 5 presents some concluding remarks.

2. International Mobility of Capital

Essential to all the issues concerning international financial integration is international capital mobility. Economists in the field of international economics are often confronted with questions such as the validity of this assumption, how to measure international capital mobility, conditions under which international capital mobility would occur and the macroeconomic policy implications of capital mobility.

There have been, broadly speaking, two lines of inquiry into the subject of international capital mobility, each taking an approach that is different from the other in the way it defines capital mobility. One line of inquiry examines the magnitude of capital flows between economies. Studies falling into this line of inquiry have evolved on the basis of a 1980 paper by Feldstein and Horioka. Although issues addressed by these studies are not closely associated with the subject matter of the current dissertation, they form an integral part of the study of international capital mobility and will therefore be briefly reviewed in

Section 2.1

The other line of inquiry, which has a long history and has remained in the main stream of the study of international economics, investigates international capital mobility by comparing rates of returns on similar financial assets in different economies. Studies falling into this category, including this dissertation, have developed on the basis of interest parity conditions. Section 2.2 will be devoted to a discussion of conceptual and methodological issues raised by interest parity conditions.

2.1. Feldstein and Horioka's view of capital mobility and the critiques

In their 1980 paper, M. Feldstein and C. Horioka (F&H hereafter) argue that perfect international capital mobility implies zero correlation between domestic savings and investment. Savings in each economy should respond to the worldwide opportunities for investment, while investment in each economy should be financed by the worldwide pool of capital. If capital mobility is limited, savings will be invested in the economy of origin. Consequently, they should have significant effects on the domestic rate of investment. F&H, therefore, argue that the extent of worldwide capital mobility may be suggested by the regression coefficient of investment on savings for each economy

$$(I/Y)_i = a + b(S/Y)_i, \quad (2.1)$$

where $(I/Y)_i$ and $(S/Y)_i$ are economy i 's ratios of gross domestic investment to GDP and gross savings to GDP respectively. Under the hypothesis of perfect capital mobility, $b = 0$

F&H examine the gross and net savings and investments of OECD economies during 1960-1974. The estimated values of b are 0.89 and 0.94 respectively, which suggests the existence of a strong correlation between domestic savings and investment. Accordingly, F&H conclude that, contrary to conventional wisdom, there is little evidence of a high degree of capital mobility among OECD countries during this period.

In the past decade, the F & H interpretation of observed high correlations between domestic savings and investment has been widely questioned. The main arguments of opponents may be best summarized by Dooley, Frankel and Mathieson (1987). For domestic savings and investment not to be correlated, three conditions must hold simultaneously. First, the rate of investment must depend on the domestic real rate of return to capital only. Any other variables correlated with domestic savings should not affect domestic investment. Second, the expected real rate of return from the rest of the world, r^* , must be exogenously determined for an economy. Third, uncovered real interest parity holds so that the domestic and world real rates of returns relevant to investment-saving decision must be equalized when measured in the same currency.

These three conditions may be represented by the three terms in the following decomposed correlation covariance between savings and investment of an economy,²

$$\text{cov}[(I/Y)_i, (S/Y)_i] = \text{cov}[e, (S/Y)_i] - \text{cov}[r^*, (S/Y)_i] - \text{cov}[(r_i - r^*), (S/Y)_i], \quad (2.2)$$

where e is a random error term that captures variables other than $(S/Y)_i$ that affect $(I/Y)_i$, and $r_i - r^*$ is the interest rate differential between economy i and the rest of the world. According

²Dooley et al. (1987).

to (2.2), the covariance between $(I/Y)_i$ and $(S/Y)_i$ is zero if and only if covariances between each of e_i , r_i^* and $r_i - r^*$ and $(S/Y)_i$ are respectively zero. If one of the three conditions fails to hold for one reason or another, the correlation between domestic savings and investment will not equal zero.

A critique most frequently made is that the high correlation between savings and investment may be attributable to the fact that both variables are endogenous. Factors generating changes in domestic savings, such as government policy, national income growth, population growth, productivity improvements, energy shocks, real wage fluctuations, also generate changes in domestic investment. Therefore, the first covariance is not generally zero. This "endogeneity" argument has been made by Tobin (1983), Dooley, Frankel and Mathieson (1987), Wong (1990), Tesar (1991) and Frankel (1992), to name a few.

Another important critique frequently made is the large economies' ability to influence interest rates, so that the second covariance in Equation (2.2) is not zero for such economies. This critique can be found in Harberger (1980), Tobin (1983), Murphy (1984) and Baxter and Crucini (1993).

Failures of real interest parities, due to various reasons such as capital controls, default risks and exchange risks, are often blamed for the non-zero third covariance. Hartman (1984), Mishkin (1984a, 1984b), Cumby and Mishkin (1986), Dooley et al. (1987) and Frankel (1991, 1992) have discussed this issue.

Since the three conditions formulated in (2.2) do not generally hold, domestic savings and investment may be highly correlated no matter what the degree of international capital mobility is. To deal with the problem of a non-zero correlation between domestic savings and

investment, economists have suggested other means of measuring capital flows, such as relative changes between ratios of current account to GDP (CA/Y) and savings to GDP (S/Y) (Caprio and Howard (1984)), or the correlation between gross domestic and gross international flows of capital (Golub (1990)).

However, conclusions drawn by studies falling into the first line of inquiry into capital mobility are not robust due to the methodological obstacle inherent in their method. As pointed out by Tesar in her 1991 critical review on the subject:

"On the surface, the correlation between savings and investment implies that the balance on the current account must be fairly stable over time. But the accounting aggregates in the identity reflect all the flows of goods, services and factors of production between the domestic economy and the rest of the world. The strong correlation between savings and investment could be the result of any of a number of forces at work in the national or international economy. Without an explicit model underlying the above identity, it is difficult to draw any conclusions from the regression analysis."³

2.2. Interest parity conditions as measures of capital mobility

If capital is mobile across economies, international arbitrage will equalize expected rates of returns on financial assets traded in different national markets, but with identical risk characteristics. Accordingly, the second line of inquiry examines international capital mobility by comparing rates of return on financial assets in different economies.

Studies using this approach depend on the substitutability between financial assets. The higher the degree of substitutability, the smaller the return differential on these assets, and the greater the degree of capital mobility. However, since financial assets are diverse, and

³Tesar (1991), p.71.

since it is difficult to find perfectly comparable assets, it is natural for this line of studies to proceed by examining interest parity conditions on relatively risk free government bonds, which are generally considered close substitutes for one another.

Covered and uncovered interest parities, as defined in the introductory chapter, have been intensively investigated. Pigott (1993) examines world interest rate differentials during 1980-93. He finds that financial integration has not led to convergence of asset returns expressed in a common currency. For instance, there were substantial uncovered interest divergences among members of the European Monetary System (EMS) over the 1980s, though their interest rates have moved closer since 1990. The change is attributable to the limited flexibility of member countries' exchange rates in the 1990s. He also notices that their long-term interest rates have achieved near-parity since 1990.

Evidence also suggests disparities among covered interest rates across economies. Dooley and Isard (1980) find deviations from covered interest parity for Germany and other European markets during 1970-74. They attribute the deviations to capital controls in Germany and the taxation of interest paid to foreign residents. Booth et al. (1985) find small differentials between the Canadian rate and U.S. rate in the 1975-82 period. Frankel (1986) discovers a decreasing differential between the three-month Euroyen interest rate and the Japanese yen rate after Japan removed its capital controls in 1984. Giavazzi and Pagano (1985) show that covered interest parity holds poorly for France and Italy in the early 1980s. Popper (1990) tests the long-term capital mobility, using the swap-covered interest parity

instead of covered interest parity usually employed for short-term assets.⁴ She finds that deviations from interest parity are almost the same among long-term assets as among short-term assets.

While many studies test deviations from nominal interest parity, real interest parity is thought to be a more relevant indicator for international financial integration. After all, it is the real interest rate on which saving and investment decisions depend. Real interest parity is defined as:

$$r - r^* = (i - \pi^e) - (i^* - \pi^{e*}).$$

Using the definition for uncovered interest parity, the real interest differential becomes:

$$r - r^* = s^e - (\pi^e - \pi^{e*}), \quad (2.3)$$

where π^e and π^{e*} are the domestic and foreign expected rates of inflation. (2.3) says that the real interest rate differential between comparable assets of two economies equals the expected nominal depreciation minus differentials in their expected inflation rates.

Tests of real interest parity have been conducted for major western countries by Friedman and Schwartz (1982), von Furstenberg and Jeon (1983), Mishkin (1984a, 1984b) and Frankel (1986, 1989, 1992). They all find significant differentials among real interest rates across economies.

⁴A currency swap contract is an agreement to exchange a stream of payments in one currency for a stream of payments in another. It is an arbitrage between long-term returns on assets denominated in different currencies. It allows a domestic investor to hold a foreign-currency denominated asset without currency risk on invested principal.

Frankel (1992) attributes the disparities in real interest rates to the currency premium.

According to him, the real interest rate differential may be decomposed as:

$$r - r^* = (i - i^* - fd) + (fd - s^e) + (s^e - (\pi^e - \pi^{e*})), \quad (2.4)$$

where r and r^* are the domestic and foreign real interest rates respectively. The first term on the right-hand side is the definition of covered interest parity, which represents, according to Frankel, the country premium because:

"it captures all barriers to integration of financial markets across national boundaries: transaction costs, information costs, capital controls, tax laws that discriminate by country of residence, default risk, and risk of future capital controls."⁵

The second and the third terms are the exchange rate premium and the expected real depreciation respectively. Together they constitute the currency premium.

Frankel studies the covered interest parity condition for twenty economies (1989, 1991). He finds that barriers to capital movements have been low for most of these economies at least as far back as 1982. Absolute values of covered interest differentials among them have declined significantly. However, many economies, Germany, Switzerland, the Netherlands, Austria, and Japan in particular, have substantial currency premiums. The currency premiums have largely accounted for real interest differentials between each of these countries and the United States since 1973, when their currencies experience considerable nominal and real exchange rate volatility. Frankel's results suggest that the highly variable currency premium

⁵Frankel (1992), p.199.

has been the main reason for the large differentials in real interest rates.

Taking a slightly different approach, studies by Hartman (1984), Swanson (1987), Cumby and Mishkin (1986) investigate the linkage between financial markets by examining interactions between the U.S. short-term interest rate and the Eurodollar rates for similar assets. Conventional wisdom is that world financial markets are sensitive to changes in U.S. interest rates, but not vice versa. However, causality tests conducted in these studies based on different reaction lags and using time series data from different periods show an increasingly significant, though less than proportional, positive response of the U.S. rate to changes in the Eurodollar rate. This suggests that the influence of European financial markets on U.S. interest rates is stronger than conventionally believed.

To summarize, the second line of inquiry into international capital mobility focuses on interest parity conditions. Studies have generally found evidence of increasing international financial integration. In particular, barriers to capital flows have been removed in most countries. However, international interest rate differentials still remain due to the currency premium.

It is worth mentioning at this point that the observed deviations from interest parity conditions are in a sense inevitable. Interest parity conditions are asset market arbitrage conditions based on expectations. However, due to various unpredictable factors and random forecast errors, actual interest rate differentials can never be fully arbitrated. Therefore, test results based on *ex post* data may not be able to reflect the real degree of international financial integration, which is by definition the equalization of expected returns on similar financial assets. This problem remains in most studies of financial integration and will be

formally discussed in the next section

3. Empirical Studies on the Integration of International Equity Markets

Although test results for interest parities reviewed in the last section may provide some insight to the understanding of international financial integration, they are more relevant to bond market integration than they are to equity market integration because interest rates on bonds are normally compared in these tests.

Conceptually, asset market arbitrage will equalize expected returns on equities and the interest rate if equities and bonds are perfect substitutes. However, equities have more varied risk characteristics and are subject to greater country barriers, such as investment regulations and different tax treatments. Therefore, bonds and equities may not be close substitutes and their expected returns may not be equal. It follows that even if interest parity conditions hold, they do not necessarily indicate that international equity markets are integrated. In order to obtain more direct insight into international financial integration, it is also necessary to examine return differentials among internationally comparable equities.

There exists a growing body of empirical literature that statistically documents the characteristics of world equity market movements. The following subsections will put into perspective the results of many empirical studies using different data sets and methodologies.

3.1. Correlations among equity markets

The main purpose of earlier studies of world equity market movements, such as

Grubel (1968), Levy and Sarnat (1970), Grubel and Fadner (1971), Ripley (1973), Solnik (1974), Lessard (1974, 1976), Panton, Lessig and Joy (1976), and Hilliard (1979), was to find out whether there was room for international portfolio diversification. As summarized in a well-known critical review by Adler and Dumas (1983), these studies generally found insignificant correlations among world equity markets during 1971-79. Therefore, investors would greatly reduce their risks by investing internationally. More recent empirical studies based on the data for the last two decades, however, have found evidence that suggests moderate to substantial correlations among world equity markets.

Generally, there are two basic methods to examine correlations among national equity markets. One method is to estimate the following simple regression:

$$\ln P_i = \alpha + \beta \ln P_j + \mu, \quad (2.5)$$

where $\ln P_i$ and $\ln P_j$ are natural logarithms of current nominal equity price indexes in terms of a common currency for economies i and j respectively, and β is the regression coefficient, indicating the degree of correlation.

There are several points about this regression that need explanation. First, equity price indexes of different economies are measured on different scales, which is captured by α . The null hypothesis is $\beta=1$ for perfect integration.

Second, since what really matters is the equalization among expected rates of returns on internationally comparable equities, it is more intuitive to estimate correlations among rates of returns. A simple way to do this is to estimate correlations among rates of changes

in national equity price indexes given that variances in dividend yields are very small

$$\Delta \ln P_i = \beta \Delta \ln P_j + \mu, \quad (2.5)'$$

where $\Delta \ln P$ is the first log difference of an equity price index.

Third, since it is difficult to obtain data for expected equity prices and equity returns, a common practice in empirical studies of international financial integration is to assume that investors possess perfect foresight so that *ex post* data may be used instead of *ex ante* data.

The second method to examine correlations among equity price indexes or equity returns is to use data in terms of local currencies. Then, regressions estimated are

$$\ln Q_i = \gamma_0 + \gamma_1 \ln Q_j + \gamma_2 \ln S_{ij}^e + \varepsilon, \quad (2.6)$$

$$\Delta \ln Q_i = \gamma_1 \Delta \ln Q_j + \gamma_2 \Delta \ln S_{ij}^e + \varepsilon, \quad (2.6)'$$

where $\ln Q_i$ and $\ln Q_j$ are natural logarithms of current equity prices measured in different currencies, $\ln S_{ij}^e$ is the logarithm of the expected exchange rate, $\Delta \ln S_{ij}^e$ denotes the expected rate of depreciation.

The rationale for estimating (2.5) to (2.6)' is straightforward. Analogous to purchasing power parity that indicates the integration of international goods markets, or interest parity that indicates the integration of international bond markets, there should exist an equity price or equity return parity condition for comparable equities in a world of perfectly integrated

equity markets given zero transaction costs. The presumption may be tested by estimating of these regressions.

Using both equations (2.5) and (2.5)', Dwyer and Hafer (1988) examine correlations among dollar-denominated U.S., U.K., Japanese and German daily equity price indexes and rates of changes during July 1, 1987 to January 29, 1988. The estimated correlation coefficients range from +0.75 to -0.56 for the pre-crash period (before October 19, 1987) and +0.56 to -0.38 for the post-crash period (after the week of October 19) respectively. This suggests that comovements were not stable before and after the crash. However, except for Japan/U.K., the estimated pairwise correlation coefficients for changes in the indexes are all positive and significant for the full period.

Similarly, Bennett and Kelleher (1988) investigate correlations among rates of changes of different equity markets for a thirty-day period surrounding the crash of 1987 and for the 1970s and 1980s, using (2.5)'. They find that correlations of the U.S./German, U.S./Japanese and U.S./U.K. equity markets were particularly high for the crash period and comovements among these markets have become increasingly stronger since the 1980s, compared to those in the 1970s and earlier.

Estimates of regressions (2.6)' by Bhandari and Genberg (1989) for fifteen pairs of G-7 countries during 1974-87 show that γ_1 's are significantly greater than zero for all country pairings, but γ_2 's are either insignificant or negative. Their results suggest that changes in exchange rates have not been systematically and positively related to relative changes in equity prices. Their explanation for this result is that real shocks other than exchange rate fluctuations have affected the equity returns in these markets differently.

Although regression models such as equations (2.5) to (2.6)' are easy to estimate, test results based on *ex post* data may not be able to reflect the real degree of international financial integration, which is by definition the equalization of expected returns on similar financial assets. This problem in empirical studies involving expectations is formally discussed by Dwyer and Hafer in their 1988 study. Given dividend yields, *ex post* equity return parity such as equation (2.6)' may be written as:

$$(\ln Q_{i,t+1} - \ln Q_{j,t+1} - \ln S_{y,t+1}) = (\ln Q_{i,t} - \ln Q_{j,t} - \ln S_{y,t}) + (\varepsilon_{i,t} - \varepsilon_{j,t} - \varepsilon_{y,t}), \quad (2.7)$$

where $\varepsilon_{i,t}$, $\varepsilon_{j,t}$ and $\varepsilon_{y,t}$ are errors associated with predicting rates of returns on domestic and foreign similar equities, and the exchange rate depreciation.

Equation (2.7) implies that *ex post* returns may differ substantially due to various unforeseen innovations captured by $(\varepsilon_{i,t} + \varepsilon_{j,t} + \varepsilon_{y,t})$ even if *ex ante* returns expected by investors are perfectly identical when measured in the same currency:

$$(\ln Q_{i,t+1} - \ln Q_{i,t}) - (\ln Q_{j,t+1} - \ln Q_{j,t}) = (\ln S_{y,t+1} - \ln S_{y,t}). \quad (2.8)$$

Therefore, differentials among *ex post* equity returns do not necessarily indicate that *ex ante* returns are not equal. This is to say that empirical results based on these models, although suggestive, cannot tell us exactly whether world equity markets are integrated or not.

Various methods have been suggested to deal with this inherent problem in using *ex*

post equity return differentials as indicators of world equity market integration. Some economists argue that if there exists a long-run stationary linear relationship between two equity prices of different economies, and if divergences from such a linear relationship are proved to be random and diminishing over time, expected equity returns should be considered equalized on average over time. This long-run equilibrium relationship is referred to in the time series study as a cointegrating relationship.

Dwyer and Hafer (1988) adopt a procedure suggested by Engle and Granger (1987) to test unit roots in the dollar-denominated equity price differentials among the U.S., U.K., German and Japanese markets using daily data for the six months surrounding the 1987 crash and monthly data for 1957-87. The finding of a unit root in the difference between two indexes indicates that the equity price differential is nonstationary and the two markets are not cointegrated

Dwyer and Hafer's test statistics cannot reject at 5 percent confidence level the null hypothesis that a unit root existed in the equity price differential of each of the six market pairs during the crash period. Neither can their tests reject the null hypothesis of non-cointegration for all pairs of indexes during 1973-87, though German/U.S. and German/U.K. markets are found to be cointegrated for a longer period from 1957 to 1987.

However, cointegration test results are generally sensitive to the test procedure used. Using alternative test procedures, such as those proposed by Johansen (1988) and Stock and Watson (1988), or more recent data, may find evidence that suggests the cointegrating

relationship among world equity markets ⁶

For instance, Kasa (1992) employs Johansen's tests to determine whether common stochastic trends existed among stock markets of the United States, England, Japan, Germany and Canada during the period of 1974-90. He finds a unit root in each of these market price indexes during the period, and evidence of a single stochastic trend lying behind the long-run comovement of these equity markets, though deviations of these markets from this trend could persist for years. Besides, tests for cointegration including more lags (over a year's worth of lags) provide much stronger evidence of cointegration. His findings indicate that the five world major markets have been closely correlated over infinitely long horizon, which implies that international diversification is of little significance for investors with long holding periods.

Campbell and Hamao (1992) investigate the U.S. and Japanese equity markets during 1971-1990 to see whether the two markets have experienced systematic comovement in the long run. Systematic comovements in equity returns suggest integration because they imply that some force must be affecting both equity markets similarly. Otherwise, equity returns on different markets would move together only by coincidence. Campbell and Hamao find a very stable correlation between the excess U.S. and Japanese monthly equity returns over the three-month U.S. T-Bill rate during 1971-90. The estimated correlation coefficients are about 0.3 for the whole sample period and all different subperiods. Furthermore, many forecasting variables have parallel effects on excess returns on both markets over the entire sample.

⁶See Dickey et al. (1991) for a detailed discussion of different procedures for cointegration tests. Definitions and applications of unit root and cointegration tests in studies of international equity markets will be formally discussed in Chapter V, Section 2.3.

period, which confirms their proposition that the same force must be affecting both markets similarly for them to comove over the long run

3.2 Persistent effect of innovations

Empirical tests such as equations (2.5) to (2.6)' are often found to be too simple to reflect adequately the true nature of international equity market integration. In recent years, various empirical models have been developed based on these simple test procedures to capture the diverse characteristics of international equity markets.

One direction of extension is to model equity market interactions that are more complicated than contemporaneous correlations. The question considered by this type of models is whether world equity markets also respond to previous market movements in each other that reflect persistent effects of economic innovations.

To answer this question, empirical studies in recent years apply vector-autoregressive analysis (VAR) initiated by Sims (1980) to the investigation of dynamic interactions among world equity markets. In the VAR model, the current equity return in each market depends on autoregressive lagged returns in its own market as well as all other markets investigated. The model provides devices such as variance decompositions and impulse functions to simulate correlations among different equity markets over different horizons.

Eun and Shim (1989) examine nine equity markets all over the world using this approach. Results produced from variance decompositions demonstrate that most of these markets have had positive and significant contemporaneous correlations. Moreover, there has been a substantial amount of dynamic interdependence. For example, significant proportions

of individual market variances, ranging from 11.02 percent for the United States to 52.02 percent for Canada, have been attributable to collective innovations in foreign markets over the horizon of twenty days.

Using the same method, Joen and von Furstenberg (1990) analyze the German, Japanese, U.K. and U.S. equity markets. Their results show that correlations among their equity price indexes have increased since 1987. The effect of a market on of its immediate subsequent market has become stronger. For instance, after-hour price movements in U.S. equities traded on the Tokyo and London markets were reflected closely in opening New York prices during January 1, 1986 to November 1, 1988. Evidence from both variance decompositions and impulse responses suggests a great deal of interaction among the major world equity markets. However, their results also show that responses to unit orthogonalized residuals after three days were insignificant.

Although the VAR approach provides a variety of procedures to accommodate various empirical tests using time series data and is easy to operate, it has some deficiencies. The VAR model has been frequently criticized for its lack of economic structure. Critics suggest that since the VAR model and other time series models do not depend on prior theoretical restrictions, test results they produce do not explain the structural relationships among the underlying variables.

The second problem is that equity price indexes are usually individually nonstationary but cointegrated with each other. In their 1987 paper, Engle and Granger demonstrate that if two or more nonstationary variables are cointegrated, the VAR model in first differences can be misspecified because, to put it simply, it ignores the information contained in the levels

of lagged dependent variables. This misspecification may be amended by adding to the regressions error-correction terms that reflect the short-term deviations from the long-run equilibrium.⁷

The third problem of the VAR approach is that results from variance decompositions are sensitive to the ordering of regression. A common treatment to this problem is to rotate the order in which the equations are placed for orthogonalization.

3.3. Lead-lag relations among world equity markets

A question frequently asked in the empirical study of international equity market integration is whether one market systematically leads movements in another market, or in all markets of the world. If the systematic lead-lag relationship exists, another question arises whether it is long enough and significant enough to exploit. Earlier studies by Grubel and Fadner (1971), Agmon (1972), Hilliard (1979), for example, detected no systematic lead-lags among different equity markets.

More recently, various empirical models, especially time series models, have been developed for causality tests. Most of these tests allow for trading time differences and the effect of new information about one market on subsequently opening markets.

Results obtained by Eun and Shim (1989) using the VAR analysis show that the U.S. equity market has been the most influential in the world and that its movements have systematically led other markets. Their estimated contemporaneous correlations between the

⁷For a technical discussion, see Engle and Granger (1987), Banerjee et al. (1993), Chapter 8, Hamilton (1994), Chapter 19, and Chapter 5, Section 4 of this dissertation.

U.S. market and the Asian-Pacific and European markets, except Canada and the United Kingdom, are low. In most cases, these markets seem to react to U.S. market innovations with a one-day or two-day lag. Among these markets, Australia and Japan have been more sluggish to respond to a U.S. shock. However, the low contemporaneous correlation coefficients are partly because these markets open before the U.S. market and can only react to innovations in the U.S. market with at least a one-day lag.

To determine directions of causality, Joen and von Furstenberg (1990) place the German, Japanese, U.K. and U.S. equity markets in different time sequences, giving each a chance to open first. The results they obtain from causality tests suggest that the pattern of leadership has changed. All markets have become more responsive to Japanese market innovations after the 1987 equity market crash, but not more to the U.S. market innovations. However, U.S. impulses have more sustained effects than the Japanese ones.

Schollhammer and Sand (1987) employ the autoregressive integrated moving average (ARIMA) technique to analyze the extent to which a change in the equity price index of one economy exerts an influence on equity prices in other economies. Their study is motivated by a presumption that not all lead-lag structures are determined by trading time differences because equity markets are not equally important internationally and markets of greater importance will lead other markets. They further assume that changes in fundamentals relevant to the U.S. equity market are likely to have stronger international impacts. Therefore, the U.S. market should be expected to lead other markets on average.

Schollhammer and Sand examine the lead-lag relationships among thirteen national equity markets using daily data over the period of January 1981 to June 1983. They find that

changes in U.S. equity prices have affected equity prices of most of the thirteen markets in the same direction on the following day. This result of the U.S. market leading other markets is consistent with the findings by Eun and Shim (1989), and Joen and von Furstenberg (1990). Besides, most European equity markets are found to have strong same-day correlations with one another due to their close economic interdependence. The Japanese market is found uncorrelated with the U.S. market during January 1981 to March 1982, but strongly lagged the U.S. market at both one and two days from April 1982 to June 1983, which is consistent with the results of many other studies.

In contrast to the above results, causality tests performed by Bhandari and Genberg (1989) on equity prices of G-7 countries cannot find any evidence of systematic lead-lags since 1974. In most cases, the equity price movements of G-7 countries seem to be contemporaneous. In a few cases where such relationships seem to be present, they do not find a pattern of lead-lag relationships. Their results are inconclusive as to whether contemporaneous equity price changes are a result of some event common to all markets or an immediate transmission of a market innovation from one country to other countries.

Koch and Koch (1991) also come to similar conclusions by investigating the nature of simultaneity across world equity markets. They estimate a dynamic-simultaneous-equation system similar to the VAR model but including five day-of-the-week dummies in each market regression. Also, the Japanese rate of return on the same calendar day is added to regressions of those markets whose trading times overlap that of Japan. The purpose of estimating "same day coefficients" is to assess responses of those markets to 1 percent change in the Japanese return within a 24-hour period.

Using this model, Koch and Koch analyze relationships among eight markets during 1972, 1980 and 1987 respectively. Among fifty-five pairs of same-day relationships, only fifteen are found to move simultaneously in both 1972 and 1980. The number rises to twenty-two for 1987. However there is little evidence of significant lead-lags beyond 24 hours, which implies that most market interactions are completed within twenty-four hours.

Beside disagreeing on whether there is a long-term pattern of lead-lag relationships among world equity markets in general, economists have also debated, and are still debating, the issue of which market initiated the crash of 1987. For instance, Roll (1988) compares daily changes of twenty-three equity markets around the crash period and suggests that the crash started from the drastic declines of the non-Japanese Asian markets on October 19, which was echoed first by some European markets, and then by North America and, finally, by Japan. Shiller et al. (1988), on the other hand, indicate that the crash was initiated by the U.S. market and then spread to the rest of the world.

Malliaris and Urrutia (1992) run bidirectional causality tests on thirty pairs among six equity markets during the crash period using an error-correction model. They find that the null hypothesis of no-causality can be rejected for twenty out of thirty pairs during October 1987. The evidence suggests that no market led New York and, except Tokyo, no market lagged New York either during the month of the crash. Beside, no market lagged Tokyo except Singapore. The null hypothesis of no-causality cannot be rejected at a 5 percent level for twenty-three out of thirty pairs for the pre-crash period (May 1, 1987 to September 30, 1987) and fifteen out of thirty pairs for the post-crash (November 1, 1987 to March 31, 1988) period.

3.4. Equity market volatility and correlations

Equity markets are characterized by volatility that creates substantial risk for investors. The volatility can be internationally contagious if world equity markets are interdependent. The crash of 1987 provides an extreme example of all major equity markets falling simultaneously despite widely different economic circumstances. Since the crash, the correlation of volatility in different markets, or from a different perspective, the correlation of world equity markets during the period of great market volatility, has been a focus of extensive empirical study. A growing body of evidence suggests that high volatility in one major market tends to spread across markets, and correlations among equity markets have been higher during periods of greater than average market volatility.

Economists attribute this phenomenon to market overreaction and contagion. When a fundamental innovation drastically changes equity prices in one market, reactions of other markets are sometimes beyond that justified by economic fundamentals. If the information structure is complex and non-fully-revealing, the situation can be exacerbated, causing speculations, even panic, which will then be rapidly transmitted to other markets, producing excessive volatility. Such excessive volatility is usually self-reinforcing and persistent for longer than would otherwise be the case.

King and Wadhwani (1990) construct a two-market contagion model to formally explain such a phenomenon. In their model, the rate of change in one equity market is regressed on information sets about its own market and the other market. A fully-revealing information set includes news about fundamentals and current price changes. Their model

based on a non-fully-revealing information set assumes that the only external information available to a market about its expected return is from observed price changes in the other market. A consequence of non-fully-revealing information is that prices in one equity market will experience bigger changes if there are bigger changes in the other equity market.

Empirically, researches have extended basic test procedures (2.5) to (2.6)' to reflect the phenomenon of high market correlations going hand-in-hand with high volatility. For instance, instead of regressing the equity price or return of one market on that of another market, Bennett and Kelleher (1988) use the standard deviation of equity price changes in the first opening market to predict standard deviations of subsequent markets that trade in the same day.⁶ The study is based on the intuition that the greater standard deviation of price changes in the starting market is felt sequentially as markets all over the world open in turn around the clock and trade based on new information.

Bennett and Kelleher find sharp and simultaneous increases in the standard deviations of nineteen major equity market indexes about their respective means during the thirty days around the 1987 crash. It is also apparent that the greater the volatility in a market, the higher the estimated correlation coefficient between its price movement and the price movement in the subsequently opening market.

The basic empirical models (2.5) to (2.6)' and all the extensions reviewed above assume that forecast errors are normally distributed with a zero mean and a constant variance of σ^2 . However, equity markets are typically characterized by time-varying variances. Engle

⁶The standard deviation of equity price movements about the mean is generally taken as an indicator of risk in the empirical finance literature.

in 1982 introduces the autoregressive conditional heteroskedasticity (ARCH) model to characterize forecast errors with constant unconditional variances, but nonconstant variances conditional on the past. Engle's ARCH model, in which stochastic errors follow an AR process only, is later generalized by Bollerslev (1990) to allow errors to follow an ARMA process. Bollerslev's extension is known as the GARCH model. The ARCH/GARCH approach is able to produce better forecasts of equity market movements since additional information from the past is allowed to affect forecast variances.

Recently, many economists have applied the ARCH/GARCH approach to study the effect of volatility in one market on volatility in another market. Hamao, Masulis and Ng (1990) employ the GARCH model to investigate transmissions of volatility across the U.S., U.K. and Japanese equity markets from April 1, 1985 to March 31, 1988. Their study first examines the very short-run, intra-day equity price activities in each individual market using close-to-open and open-to-close daily returns. They then introduce an exogenous variable into the conditional variance. This variable, the squared forecast error from the last open foreign market, represents the most recent foreign surprise. The purpose is to see how this most recent foreign surprise may affect the variance function of the domestic market. Their results indicate significant volatility spillovers from the U.S. and U.K. markets to the Japanese market and from the U.S. to U.K. markets. However, no volatility spillovers in other directions are found for the pre-crash period.

Lin, Engle and Ito (1994) investigate the correlation of volatility of the U.S. and Japanese markets using the GARCH model. Their work is an extension of King and Wadhwani (1990). In this model, returns of individual markets are regressed on their own

daytime and overnight returns, a holiday dummy and an intra-day forecast error on foreign returns. In this way, unexpected changes during trading hours are incorporated in a timely fashion into the equity price of each market. Their model predicts that the correlation coefficient between foreign daytime and domestic overnight returns is time-varying when shocks have GARCH effects. Besides, contemporaneous spillovers, or effects of the daytime volatility of one market on the overnight return of another market, are bidirectional. However, they find few lagged spillovers from the daytime volatility of one market to the subsequent daytime returns of another market in either direction.

Other recent important studies on the correlation of volatility using ARCH/GARCH models include Kim and Rogers (1993) for the Korean, Japanese and U.S. markets and Susmel and Engle (1994) for the U.S. and U.K. markets. Both studies find evidence of transmission of volatility across markets.

To summarize Section 3, while different in research methods, time horizons and data, the empirical studies reviewed in this section suggest the following stylized facts of correlations among world equity markets.

First, equity prices of the world major markets have been positively correlated in general since the world market crash in 1987, though statistically significant negative correlation can sometimes be detected, especially before the 1980s. Second, the correlations have become increasingly significant since the 1980s. Third, correlations among world equity markets are usually positively related to the volatility in these markets. Fourth, differences in equity returns expressed in local currencies have not been systematically offset by exchange rate fluctuations. Fifth, the estimated positive correlations for relatively longer

investment horizons are more stable and evident than the correlations on a daily basis. Sixth, although there have been lead-lag relationships among equity markets, there is no consensus as to whether any equity market, the U.S. equity market in particular, systematically leads other markets. However, it seems that the U.S. market does not lag other markets.

4. Economic Fundamentals and the Integration of World Equity Markets

The empirical studies discussed in Section 3 document how much and how fast different national equity markets react to innovations in each other, disregarding the causes of innovations. As the body of empirical literature on this topic grows, a number of empirical and theoretical studies have emerged to investigate some more profound issues. Such issues include what fundamentals affect equity markets worldwide, how innovations in fundamentals and macroeconomic policies travel across equity markets, how much international equity markets are correlated in response to economic innovations, and so on. These studies, which are motivated to find the true structural relationship between world equity market movements and the underlying fundamentals, have generally taken three approaches.

One approach is the international capital asset pricing model (IAPM). Since risk factors are important in the determination of equity prices and equities of different economies are very much differentiated with respect to risk, an adequate model of risk pricing is therefore crucial for sensible international comparisons of equity prices and returns. The existing IAPM literature discusses the specification of such a model.

There are, broadly speaking, two versions of IAPM separated by their different measures of risk. In consumption-based asset pricing models, the risk of an asset is measured

by the covariance between the real return on the asset and the real growth in the consumption of an investor. An international comparison of asset risks then involves a comparison of different economies' marginal rates of intertemporal substitution between consumption and savings. This inevitably requires that investors of different economies have identical tastes, similar utility functions and use price indexes measured in the same currency to deflate their consumption possibilities, which in turn implies that purchasing power parity for goods markets must hold.

In mean-variance asset pricing models, the risk of an asset is measured by the covariance between the real return on the asset and the real return on the world market portfolio. The model predicts that, if international equity markets are integrated, the world market portfolio will be mean-variance efficient. However, unlike CAPM in which the return on any equity is a linear function of the return on the domestic market index, a realistic and mean-variance efficient world index is difficult to obtain due to diverse national factors.

In the past decade, the IAPM literature has been an object of intense controversy about different assumptions of utility functions, uncertainties, market imperfection and the existence of a mean-variance efficient world portfolio. However, since issues addressed by this dissertation are based on the assumption that national equity price indexes are mean-variance efficient and are in similar risk classes, risk pricing is assumed away. Therefore, in order to keep this review on track, the IAPM literature will not be further discussed.

The following two subsections focus on the other two approaches in investigating links between economic fundamentals and equity market integration. One of the approaches analyzes world equity market reactions to economic events or fundamental innovations. The

purpose is to identify economic fundamentals that induce world equity price comovements and to test empirically some specific theoretical predictions.

The other approach extends the Mundell-Fleming-Dornbusch type of open economy macroeconomic models by introducing the equity market into such models. Studies falling into this category are mostly theoretical and their primary focus lies on issues that have broader macroeconomic and policy implications

4.1. Economic fundamentals and comovements of international equity markets

Studies focusing on domestic equity markets have long identified some important domestic economic factors that significantly influence returns on domestic equities. Such factors include dividend yields, expected rates of currency depreciation, spreads between long and short interest rates, nominal and real interest rates, aggregate domestic economic activities, performances of particular economic sectors or firms, and more.⁹ Among these studies, Chen, Roll and Ross (1986), Campbell (1987, 1990), Campbell and Shiller (1988), Fama and French (1988, 1989) and Fama (1990) are well known. Questions then remain as to what and how economic fundamentals may affect equity returns worldwide

In an attempt to identify fundamental determinants for world equity returns, von Furstenberg and Joen (1989) investigate four major world markets using daily data. The theoretical basis underlying their analysis involves Tobin's Q approach to investment and a Dornbusch-type exchange rate determination process. The former predicts that the market

⁹The spread between long and short interest rates indicates the expected rate of inflation and the expected rate of depreciation in the long term

value of equity claims depends on expected returns to capital, which are in turn determined by the ratio between the marginal value of capital installation and the cost of capital installation. Given other conditions, a higher cost of capital lowers the expected return and reduces the price of equity claims.

One factor that frequently affects the cost of capital is the fluctuation in the price of oil, which is often used as an input in producing capital. It follows that the negative impact of the increased oil prices on potential growth should be larger on economies poorly endowed with oil, such as Japan and Germany, than on relatively oil-rich economies, such as the United States. However, von Furstenberg and Joen find that oil price increases have not consistently depressed the average equity price in either Japan or Germany, though they do have a positive effect on the U.S. equity price.

The Dornbusch model is referred to in their study for the analysis of how interest rate differentials and expected depreciations affect equity prices. According to the Dornbusch model, if the central bank adopts an expansionary monetary policy, there will be lower interest rates and an expected appreciation after the initial overshoot. The lower real interest rate will reduce the cost of debt-financed capital. The expected appreciation will induce international investors to hold domestic assets. Thus, given other conditions, expansionary monetary policy unambiguously increases domestic equity prices. On the other hand, a fiscal contraction, which lowers interest rates as well as aggregate demand, may have an ambiguous effect on equity prices.

However, available empirical evidence is not consistent with these theoretical hypotheses. Exchange rate depreciations were negatively correlated with the U.S. market, but

positively correlated with the German equity market. Moreover, the negative relationship between interest rate differentials and equity prices does not seem to hold for the markets examined except the United States. In particular, interest rate differentials between the United Kingdom and other economies grew noticeably in 1988 without depressing its equity market.

Unable to link equity price movements with broad economic fundamentals, von Furstenberg and Joen (1989) break down the overall indexes into industry subgroups to find explanations to unequal changes in national equity markets. They suggest that correlations between the same industries' equity price averages may range from negative to positive depending on the type of news. If the news produces redistributive effects, such as a major improvement in the industrial productivity of one economy that may lure investors away from the same industries of other economies, the industry equity price averages of different economies will be affected differently. If the news is about isolated events, such as mergers that do not indicate major changes in fundamentals, no comovement of industry averages in different economies is expected. Finally, if the news concerns the industry as a whole irrespective of individual economies, such as a worldwide shortage or a major price change of an input, positive correlations among industry averages are expected. However, their empirical results show that industry effects do not seem to explain international equity price variations in a particular industry. To summarize, their study fails to specify any fundamental factor that significantly accounts for the increasing correlations of world equity prices after the 1987 crash.

To determine the degree to which foreign economic variables and equity market movements explain domestic equity market movements, Remolona (1991) runs a series of

tests using quarterly data of the U.K., U.S. and Japanese economies from January, 1973 to September, 1990. Excess equity returns over three-month T-Bill rates of individual economies are first regressed on their respective domestic lagged dividend yields, excess bond returns and four quarterly leads of real growth rate in GNP. Then real growth rates four periods forward in the other two economies are added to the regressions to see whether the addition of the future foreign growth increases the predictive power of each regression.

Estimated results based on this model are poor, which are probably because, as Remolona suggests, changes in foreign fundamentals may not influence the domestic equity market directly. Their effects may be first reflected in the foreign equity market and then passed on from the foreign market to the domestic market. To verify this possible link, future foreign real growths in regressions are replaced by foreign equity returns that reflect expected foreign fundamentals. The gain in the explanatory power is significant for the U.S. and Japanese equity markets.

In order to determine whether foreign variables have any predictive power when they are added to the regression for domestic excess returns, Campbell and Hamao (1992) regress the U.S. and Japanese excess returns on a common set of fundamental variables of both economies, such as the dividend-price ratio, and the short-term and long-term interest rates. Their estimates indicate that the overall forecasting power of U.S. variables on the Japanese excess equity return has been significant, but not *vice versa*. In particular, the price-dividend differential between Japan and the United States is a powerful forecasting variable for Japanese returns. Their results reject at a 5 percent level the hypothesis that excess equity returns in the two economies are perfectly correlated.

In a similar study, Ammer and Mei (1993) suggest that in a fully integrated economic system, labor and capital should move freely across economies. This should eliminate international differences in technology and production costs. It follows that a shock should have similar impacts on growth rates, earnings and dividends of different economies. Their study then decomposes shocks in equity returns into changes associated respectively with future dividends, real interest rates, and the equity risk premium defined as the excess return on equity over the three-month T-Bill return. *Ceteris paribus*, expected higher real interest rates negatively influence the current equity returns, and greater future dividends or expected higher future excessive equity returns positively affect current equity returns. It follows that the degree of international equity market integration can be measured by correlations between changes in equity returns and different components of these expected changes.

They estimate the variance-covariance matrix of these components in a present-value model. For the U.S. and U.K. equity markets during 1957-89, their results suggest the following. First, the correlation between equity returns of the two economies is substantially greater than the correlation between their real rates of economic growth. Second, news about future shifts in risk premiums accounts for a large part of the variation in current returns of each market. Third, the covariance between equity return innovations in the two markets is a sum of twelve components. Among the twelve components, correlated news about future dividend growth in these two economies and correlated news about future risk premium make the largest contributions to the total covariance.

Ammer and Mei then apply the same methodology to estimate the variance-covariance matrix of future dividends, real interest rates, and the equity risk premiums of fifteen

industrialized economies. They find that news about future dividends of different economies is more significantly correlated than shocks to contemporaneous outputs of different economies in most cases. This suggests that there are lags in the international transmission of real economic shocks and that the financial linkages are stronger from a long-run perspective than from a short-run perspective.

Bailey (1989) conducts an event study on reactions of nine equity markets of the Pacific Rim economies to the U.S. monetary surprises during October 1977 to September 1985. The study tests basically two hypotheses. The first hypothesis is that the stronger the link between an economy and international capital markets, the more responsive is its equity market to the U.S. monetary news. His test results support the hypothesis. Among the nine economies examined, the U.S. monetary policy systematically affects equity indexes of Australia, Japan, Hong Kong, Singapore and Malaysia, which have little control on international capital movements.

The second hypothesis suggests that the more an economy exports to the United States, the more its equity market responds to a rise in the U.S. excess money supply due to the expected increase in U.S. consumption. However, his tests fail to show a reliable pattern of the relationship between exports to the United States and equity market movements in response to the U.S. monetary news. For instance, the regression coefficient for Australia is significant despite its relatively small exports to the United States. Those for Korea and Taiwan are insignificant despite their relatively large exports to the United States. The non-intuitive results may be because expansionary monetary policy only has a short-run impact on consumption.

Other event studies focusing on the relationship between economic fundamentals and the comovement of world equity markets include Brown and Warner (1985), Hartigan et al. (1986), Grossman and Levinsohn (1989), Peterson (1990), Baily (1990), Cornett and Tehranian (1990) and Thompson (1991a, 1991b), to name a few.

To summarize this section, many studies have tried to explain structural relationships between fundamentals and comovements of world equity markets. Although they suggest similar international transmission mechanisms of economic innovations across equity markets, such as trade volumes, interest rates, the exchange rate, and the most prominent of all, equity prices themselves, their empirical results are not completely consistent with theoretical predictions. Some studies, such as Ammer and Mei (1993), and Campbell and Hamao (1992), find empirical evidence of linkages between equity price movements across markets and the broad economic fundamentals. Others, such as von Furstenberg and Joen (1989), Bailey (1989) and Remolona (1991), fail to establish such links but find that the link between equity markets of different economies is stronger than the link between the equity market of one economy and fundamentals of another. This is most likely because investors in one equity market view an innovation in another market as reflecting innovations in fundamentals. Thus equity markets of different economies serve as a conveying channel through which fundamentals of one economy influence the equity market of another.

4.2. Theoretical characterization of international equity market integration

It is apparent from the results of the above studies that innovations in fundamentals are transmitted across markets through various channels. Therefore, no single theoretical

model, no matter how sophisticated, is able to characterize adequately most of the stylized facts about world equity markets. However, the observed world equity market comovements suggest that there should be certain common elements that govern such behavior. Several studies attempt to summarize theoretically some of these elements. Most of them try to introduce the equity market into Mundell-Fleming-Dornbusch open economy models so that international transmission mechanisms for national fundamental changes can be characterized with the presence of the equity market.

In his 1986 study, Gavin constructs a dynamic small open economy model in which national output, the equity price and the real exchange rate are jointly determined.¹⁰ The real equity price is the present value of anticipated future profits discounted at the real interest rate. The growth in output represents a proxy of domestic fundamental determinants of the equity price since it implies a higher profit and a higher or lower interest rate depending on the nature of the growth. The growth also changes the exchange rate, which reflects relative fundamentals between economies.

According to Gavin's model, the presence of the equity market may produce some unconventional results. For instance, an expansionary monetary policy reduces interest rates at home, and this unambiguously and immediately raises the price of equity, though the steady-state equity price remains unchanged because expansionary monetary policy should not produce any real effects on the economy in the long run. In the short run, however, the higher equity price increases the output due to wealth effects, which in turn further raises the equity price. The steady-state nominal exchange rate also goes up, or depreciates in

¹⁰The model is an open-economy extension of Blanchard (1981).

proportion to the increase in the money supply. However, given the assumption that the goods price is not flexible, the real exchange rate may appreciate immediately after the monetary policy. This "reverse overshooting" is possible if the interaction between output and the equity price is so strong that it raises the interest rate after the monetary policy. The appreciation will then dampen the output growth and the interaction between output and the equity price will start to work in the opposite direction.

Alternatively, a fiscal expansion raises output, the interest rate and induces an immediate appreciation, thereby producing offsetting effects on the equity price. The net effect on the equity price again depends on whether the interaction between output and the equity price outweighs the negative effect of the appreciation on output, thereby on the equity price.

Although Gavin's model does not address the issue of international financial integration, it provides important insights into how the introduction of an equity market may alter the dynamics of an otherwise conventional small open economy model.

Taking the analysis a step further, Bhandari and Genberg (1989) construct a symmetric-two-country model in an attempt to find links among asset prices, the exchange rate and fundamentals in the domestic and foreign countries. Their model is a two-country extension of Gavin's model and an elaboration of the existing two-country models such as Turnovsky (1986a), amended to incorporate equity markets. In their world, both goods markets and asset markets of the two economies are integrated to reflect cross-country effects of economic news and policy disturbances.

The model produces standard domestic effects of an expansionary monetary policy.

The monetary policy does not affect any real variables in steady state, but induces equiproportional increases in the steady-state price and the nominal exchange rate. In the short run, the real interest rate is reduced due to the expansionary monetary policy, which will result in higher output and profit, given prices are inflexible in the short run. It follows that the domestic equity price will necessarily increase.

The effects of a domestic monetary expansion on the foreign equity price is ambiguous due to its two conflicting effects on the goods market. On the one hand, the domestic currency depreciates with the lower domestic interest rate, which will in turn reduce the demand for foreign output. On the other hand, domestic output rises due to the monetary expansion, which will in turn stimulate foreign output. Consequently, effects of a domestic monetary expansion on foreign profits, and therefore on the foreign equity price, cannot be determined. This result suggests that national policy innovations may not necessarily affect equity markets of different economies similarly.

A domestic fiscal expansion raises domestic nominal and real interest rates. The higher nominal interest rate produces an immediate appreciation and, according to the asset market arbitrage condition, reduces the domestic real equity price. The effect of this policy on the foreign equity price is again not clear. Although the increased domestic output and the appreciation will stimulate foreign output and exports and, therefore, affect the foreign equity price positively, the higher foreign output may raise foreign interest rates given other conditions, which will in turn affect the foreign equity price negatively.

The major contribution of the Bhandari-Genberg model is that it explains theoretically why equity prices across economies may not be correlated even if equity markets are

interdependent. Their analytical results show that both fiscal and monetary policies of an economy may have ambiguous effects on foreign economic fundamentals, and therefore have ambiguous effects on foreign equity markets.

Since the 1980s, macroeconomic models with microeconomic foundations have become increasingly popular in policy evaluation exercises. Such neoclassical models combine rigorous derivations of economic functions, which is typical of microeconomic models, with policy effect analyses, which are the focus of traditional macroeconomic models. Macroeconomic policy effects derived from such models can reflect the decision-making process of optimizing agents on output, consumption, savings, investment, and so on. Furthermore, the empirical implementation of this type of theoretical model may yield parameters consistent with microeconomic foundations.

Murphy's optimizing small-open economy model (1989) is an application of such a neoclassical approach to the analysis of equity-price determination and policy effects on the equity market. The policy issues addressed by Murphy are similar to those by Gavin and Bhandari-Genberg. However, the approach is quite different. In what follows, Murphy's model will be discussed in detail since the theoretical model constructed in the next chapter is a two-economy extension of his model.

Murphy investigates the dynamics of the equity price and capital accumulation in an infinite-horizon optimizing model of a small open economy that produces both traded and nontraded goods. The price of equity in his model is determined by the marginal value of newly installed capital and the profit expectations of capital investments. Capital investment decisions are made by optimizing competitive firms in a fashion that is consistent with

Tobin's Q . The relative price of nontraded goods in terms of traded goods ($P = P_N/P_T$) is referred to as the real exchange rate. Macroeconomic policies affect economic fundamentals, such as the relative price in the domestic goods market, the real interest rate, the real exchange rate and expected profits. These fundamentals in turn determine the equity price--an important factor in the decisions of investment and wealth accumulation

Dynamics of capital accumulation and the equity price in the model derived from the constrained income maximization behavior of firms can be expressed as functions of factors that reflect economic fundamentals:

$$q = H(q, K, G_N, \tau, r), \quad (2.9)$$

$$\dot{K} = F(q, K, G_N), \quad (2.10)$$

where q , K , G_N , τ and r denote the equity price, the stock of capital, government spending on nontraded goods, the tax rate and the real interest rate respectively. The installation of capital is subject to a cost of using both traded and nontraded goods.

Murphy's analysis demonstrates that different macroeconomic policies may induce qualitatively different adjustments of the capital stock and the equity price. For instance, a permanent tax cut increases the post-tax return on equity, thereby increasing the demand for equity claims. Since, by assumption, the capital stock cannot change in the short run, there needs to be an immediate overshooting of the equity price above its long-run equilibrium level to restore equity market equilibrium.

Given the real exchange rate, the higher price of equity induces an increase in

investment that will produce two effects. On the one hand, capital accumulation will eventually make the equity price fall from its short-run level. At the new long-run equilibrium, the equity price is higher than its initial level. On the other, capital accumulation increases the demand for nontraded goods, which leads to a real appreciation implied by a higher relative price of nontraded goods. However, the appreciation will induce a greater supply of nontraded goods that will moderate the impact of the initial appreciation.

By a similar argument, a temporary tax reduction causes an immediate jump in the price of equity, though the jump is smaller than in the case of a permanent tax reduction. The higher equity price encourages real investments, which in turn induces a real appreciation. After the tax rate returns to its initial level, the economy adjusts along its original stable path, with the equity price rising, the capital stock falling and the domestic currency depreciating.

An increase in government spending on traded goods does not affect the equity price, the capital stock or the real exchange rate because the price of traded goods is exogenous for a small open economy. In contrast, greater government spending on nontraded goods will alter the market equilibrium for nontraded goods, thereby inducing changes in the exchange rate, the equity price and the capital stock.

A permanent increase in government spending on nontraded goods increases the relative price of nontraded goods, and therefore produces a crowding-out effect on investment. The higher P_N , or the real appreciation, indicates an increased capital installation cost, which discourages investment. It also implies lower expected returns to capital, which reduces the equity price. As the capital stock declines and becomes more scarce, the equity price rises and the real exchange rate appreciates.

A temporary increase in G_N will produce similar immediate effects as in the case of a permanent increase of G_N , but to a lesser extent. When G_N returns to its initial level, the economy will experience an increase in the capital stock accompanied by a gradually declining equity price and a real appreciation.

A permanent reduction in the world interest rate immediately increases the domestic equity price as asset holders shift their asset holdings from the less attractive international bond into equity. The higher equity price leads to an increase in investment and a real appreciation. As capital accumulates, the equity price will fall and the real exchange rate will continue to appreciate. A temporary reduction in the world interest rate can be analyzed in a similar way as a temporary tax rate reduction.

Murphy's well-structured small open economy model has made an important contribution to modeling theoretically the determination of the equity price. However, like many small open economy models, his model does not provide the scope to pursue on the international level questions such as how equity prices in different economies react to each other and how they jointly react to common or uncommon economic news.

5. Concluding Remarks

This chapter has reviewed the empirical and theoretical literature of international financial integration. The review puts some important issues on the subject into perspective.

An issue that is essential to the entire literature is how to define, and accordingly, how to measure international financial integration. Although there have been various suggestions, many empirical studies measure the degree of the integration by comparing rates of returns

on assets traded on different markets but sharing the same risk characteristics. This approach is based on the definition that, given zero transaction costs, international financial integration indicates the equalization among expected rates of returns on comparable financial assets when expressed in a common currency.

Using this approach, a considerable number of empirical studies have investigated the integration of international equity markets. Issues addressed by these studies are the degree and structure of correlations among world equity markets and international transmission mechanisms of innovations across markets.

The simplest empirical model to evaluate contemporaneous correlations among equity markets is to regress the current equity return or equity price of one economy on the current equity return or equity price of another economy. This simple method has been extended into various directions to reflect more complicated natures of the correlations. For instance, autoregressive lagged returns are added to the regression to reflect persistent effects of innovations on different markets and lead-lag relationships among markets. The unit root test is applied to residuals of the basic model to determine whether two equity markets have a stable equilibrium relationship over the long run. Error-correction terms are introduced into the regression to estimate market adjustments to their previous deviations from the long-run equilibrium. More recently, effects of previous foreign forecast errors are allowed to affect predictions of domestic current returns.

Major findings from the empirical studies, based on either the basic model or the extended models, are the following. First, world equity markets have been positively but less than perfectly correlated in recent years. Second, the integration of international equity

markets is more of a long-run phenomenon. Third, correlations among equity markets are more prominent when markets are more volatile. Fourth, changes in exchange rates have not been able to explain equity return differentials between nations. Fifth, the correlations are often non-contemporaneous. Sixth, results are mixed about which market systematically leads other markets.

There is a growing body of literature that focuses on some more profound issues about international equity market integration, such as the structural relationship between movements of world equity markets and underlying economic fundamentals, and transmission mechanisms of economic innovations across equity markets.

Important transmission mechanisms are found to arise from trade that produces repercussion effects of real economic activities, interest rates that reflect macroeconomic policies, exchange rates that measure relative fundamentals among economies, and equity markets themselves that signal innovations in fundamentals. However, except the last factor, empirical results are mixed about whether the causal links between these factors and world equity market movements are robust.

A few theoretical studies have tried to formalize these mechanisms by introducing equity markets into traditional open economy macroeconomic models. The analytical results from two-country models show how policy changes in one country may affect relative fundamentals of different economies differently, thus influencing their equity markets differently. Attempts have also been made to analyze effects of macroeconomic policies on the equity market in a small open economy model with microeconomic foundations.

However, it is evident from this review that the theoretical literature on international

financial integration has not progressed in proportion with the corresponding empirical literature. Apparently, a void exists in formalizing international transmission mechanisms of innovations across equity markets in a macroeconomic framework that is consistent with both domestic and foreign microeconomic foundations.

As an attempt to fill this void, the current dissertation will develop a two-country macroeconomic model that incorporates optimal investment decisions and fundamental determinants for equity returns into an otherwise conventional two-country open economy macroeconomic model. The model will extend Murphy's small-open-economy model to a setting in which the dynamics of underlying variables in each economy will reflect optimizing behavior of agents in both economies. It will also add an extra dimension to policy issues that are the central concern of traditional macroeconomic models because it allows for the role of equity markets in the international transmission of economic innovations. The model will provide a useful theoretical framework in which the nature of the integration of international equity markets can be examined. Analytical results from the theoretical model will then be empirically tested using time series models.

CHAPTER III

A TWO-COUNTRY THEORETICAL MODEL

1. Introduction

This chapter discusses a symmetric-two-country macroeconomic model with microeconomic foundations. In the model, investment and the equity price of each economy are determined by the expected return on its capital, which is in turn affected by the fundamentals of both economies, such as government expenditures, tax rates and real interest rates. The primary objective is to characterize theoretically the long-run and short-run movements and comovements of world equity markets summarized in Chapter II, and to formalize the open economy macroeconomic mechanisms that govern such movements.

The outline of this chapter is as follows. Section 2 discusses basic assumptions underlying the theoretical model. Each economy is then organized into four sectors: the goods-producing industries, the capital-supplying industry, households and the government.

In Section 3, competitive firms in the goods-producing industries employ capital and labor to produce traded and nontraded goods. The supply of goods is an important aspect of domestic and international goods market equilibrium conditions, which determine the relative prices of nontraded goods in terms of traded goods in the two economies, and the relative price between the two economies. Both sets of relative prices are fundamental factors in this model.

Section 4 contains a detailed discussion of equity market equilibrium conditions. The demand for equity claims is reflected in the asset market arbitrage condition. Asset investors of both economies maximize expected returns on their asset holdings by continuously adjusting their portfolios. As a result, expected returns from all domestic and foreign assets are equalized. The supply of equity claims depends on the size of the capital stock. Optimal

capital installation decisions are made by competitive capital-producing firms in a way that is consistent with Tobin's Q theory

The behavior of infinitely-lived households is then discussed in Section 5. These households own equity claims and bonds, and maximize the present discounted value of their lifetime utility from a stream of consumption of traded and nontraded goods subject to a wealth constraint.

Section 6 describes how the government collects taxes, issues bonds, purchases both goods subject to a financing constraint.

The three sectors discussed in Section 4, 5 and 6, (i.e., investment, households consumption and government spending), represent the demand for goods, which is another aspect of domestic and international goods market equilibrium conditions that determine the relative prices. These equilibrium conditions are discussed in Section 7.

Finally, in Section 8, the solution of the model is derived from a simultaneous differential-equation system in which the dynamics of equity prices, capital accumulations and the exchange rate of the two economies are determined by the world average and relative economic fundamentals.

2. Basic Assumptions of the Model

The basic assumptions underlying this theoretical model are as follows:

- (1) The theoretical world is composed of two symmetric economies identical tastes and

identical production technologies that exhibit constant return to scale.¹¹

(2) Agents possess perfect foresight.¹²

(3) The stock of money in each economy is held constant. The analysis focuses on real variables only

(4) Each economy produces a nontraded good, a composite traded good and capital. The nontraded good in each economy can be consumed by households, used as an input in installing new capital, and purchased by governments to produce public goods. The traded good may be consumed at home, traded freely on the world market, used as an input to produce capital goods, and purchased by governments. The traded goods produced by different economies are perfect substitutes.¹³ The nontraded and traded goods are imperfect substitutes. Capital is employed in the production of both goods. Sector-specific assumptions will be discussed in the following sections.

(5) There are three relative prices to be considered in the model. The relative prices of nontraded goods in terms of traded goods in the domestic and foreign economies are defined as $P = P_N/P_T$ and $P^* = P_N^*/P_T^*$ respectively. They are endogenously determined by the local goods market equilibrium. The relative price between the two economies is defined as the real

¹¹The assumption of symmetry is useful. It greatly simplifies the model and produces conclusions that are more general and robust.

¹²Perfect foresight is a strong assumption. In the real world, unforeseeable events affect an economy's dynamic adjustment and steady state. However, this assumption is made to simplify the theoretical analysis and avoids the complication of specifying and solving a stochastic dynamic model.

¹³The elasticity of imports of traded goods with respect to the relative price of traded goods between the two economies is crucial to the stability of balance of payment adjustments. The assumption that traded goods of the two economies are perfect substitutes implies that the elasticity is infinite, which removes any possibility of instability.

exchange rate E , which is given as

$$E = S \frac{P^*}{p},$$

$$p = P_N^\eta P_T^{(1-\eta)}, \quad p^* = P_N^{*\eta} P_T^{*(1-\eta)},$$

where S denotes the nominal exchange rate, p and p^* are weighted average price indexes, and η is the expenditure share of an economy on nontraded goods. Assuming symmetry, η is the same for both economies. The prices of the composite traded goods are determined by the world goods market equilibrium and are therefore the same for the two economies when measured in the same currency. This requires that the law of one price hold for the two composite traded goods such that $S = P_T/P_T^*$, which implies that the real exchange rate is a function of the relative prices of nontraded goods only:

$$E = \frac{S P_N^{*\eta} P_T^{*(1-\eta)}}{P_N^\eta P_T^{(1-\eta)}} = \frac{P_T}{P_T^*} \frac{P_N^{*\eta} P_T^{*(1-\eta)}}{P_N^\eta P_T^{(1-\eta)}},$$

$$E = \left(\frac{P_N^*/P_T^*}{P_N/P_T} \right)^\eta. \quad (3.1)$$

An increase in the domestic price of the nontraded good leads to real appreciation or a decrease in E , and vice versa.

(6) Capital is perfectly mobile between sectors with zero adjustment costs. Capital is also

perfectly mobile between nations with zero transaction costs so that expected rates of returns on financial assets of the two economies are equalized if these assets have identical risk characteristics. This implies that the real interest parity condition holds, which is given by:

$$r = r^* + \dot{E}^e, \quad (3.2)$$

where r and r^* are real interest rates of the two economies measured in their respective consumption price indexes and $\dot{E}^e$ denotes the expected rate of depreciation of the real exchange rate.¹⁴

The formation of exchange rate expectations is given by

$$\dot{E}^e = -\theta (E - \bar{E}), \quad \theta > 0, \quad (3.2)'$$

where θ is the adjustment coefficient and $\bar{E}$ denotes the steady-state real exchange rate. The real exchange rate is expected to depreciate in proportion to the discrepancy between the current real exchange rate and the steady-state real exchange rate.

(7) There is a given amount of labor in each economy. All workers are equally skillful in producing both goods and are free to move between sectors within each economy with zero

¹⁴There are two points about this assumption that need to be explained. First, it is consistent with Assumption 5. The distinction between traded and nontraded goods has an important impact on the real interest rate differential through its effect on the real exchange rate. An economy with a falling relative price of nontraded goods due to supply or demand shocks will expect the local currency to depreciate, which means that the local real interest rate is higher than the foreign real interest rate. Differentials between real interest rates measured in consumer price indexes will therefore reflect rates of change of deviations from purchasing power parity over time. See Dornbusch (1988), Chapter 13 for a further discussion.

Second, the available empirical evidence suggests that this assumption does not always hold, especially in the short run, mainly due to exchange rate fluctuations. However, as explained in Chapters I and II, this assumption can be considered a close approximation of reality if it holds on average in the long run.

adjustment costs. The immobility of labor between nations implies that the supply of labor within each economy is inelastic.¹⁵

(8) Factor prices are flexible so that factor markets always clear. This implies full employment of labor and capital.

All variables with an asterisk denote foreign variables

3. Production of Traded and Nontraded Goods

In each economy, the production of goods is carried out by many competitive firms, each producing either traded or nontraded goods. Firms in each sector share the same constant-return-to-scale Cobb-Douglas production function.

By assumption, the nontraded goods sector, such as insurance, real estate, transportation, public utilities, financial services, wholesale and other services, uses a relatively labor-intensive technology, and the traded goods sector, such as agriculture, forestry, fisheries, mining, durable and nondurable manufacturing, uses a relatively capital-intensive technology. It is also assumed that there are no factor-intensity reversals.

The supply of traded or nontraded goods depends on the relative price of nontraded goods in terms of traded goods and the capital used in producing both goods.

¹⁵This assumption and the assumption of no factor-intensity reversal have two implications. First, labor used in each sector of production (i.e., the nontraded-goods sector, the traded-goods sector and the capital-producing sector) should be relatively fixed at each point in time and does not change significantly over time. Labor is therefore exogenous to the model. Second, the movement of labor among sectors is subject to non-factor-intensity-reversal so that the capital-labor ratio in each sector of production will not change qualitatively.

In order to simplify model construction and to concentrate on the relationship between capital and the equity price, labor and the cost of labor will be suppressed in the model wherever possible.

$$Y_N = f(P, K), \quad f_1 > 0, \quad f_2 < 0,$$

$$Y_T = g(P, K), \quad g_1 < 0, \quad g_2 > 0,$$

$$Y_N^* = f^*(P^*, K^*), \quad f_1^* > 0, \quad f_2^* < 0,$$

$$Y_T^* = g^*(P^*, K^*), \quad g_1^* < 0, \quad g_2^* > 0,$$

where Y_T , Y_T^* , Y_N and Y_N^* are outputs of traded and nontraded goods respectively, P and P^* are the relative prices of nontraded goods in terms of traded goods as defined in Assumption (5).

A higher relative price of nontraded goods will shift resources into the nontraded sector, thus increasing the output of nontraded goods. A higher domestic relative price of nontraded goods indicates a real appreciation, which induces demand from domestically-produced traded goods to foreign-produced traded goods. The reverse is true for the foreign economy when there is a depreciation of the real exchange rate.

Given product prices, an increase in the capital stock, according to the Rybczynski effect, leads to an increase in the output of the sector that is relatively capital-intensive and a decrease in the output of the sector that is relatively labor-intensive.

The production of goods also uses labor as an input. However, labor is of minor importance in determining the dynamics of the current model and will therefore be ignored (see footnote 16 below).

4. Asset Market and Capital Investment

It is assumed that only firms in the capital-supplying sector issue equity claims and only households own equity claims.¹⁶ The asset market in each economy acts as a link between households that maximize expected returns on their equity claims by choosing an optimal portfolio and firms that maximize their profit by making optimal investment decisions. The mechanism of such maximizing behavior is reflected in the asset market equilibrium condition.

In Section 4.1 and 4.2, fundamental determinants of the demand for and the supply of equity claims will be discussed respectively.

4.1. Asset markets

There are two assets in each economy. The first asset is a bond issued by the government as a means to finance its expenditures. The government pays a fixed real rate of return to the bond holder. The second asset consists of equity claims on capital issued by the capital-supplying firms. Households hold and trade all assets of both economies based on expected rates of returns on these assets.

World asset markets are efficient in the sense that market values of assets reflect all available and relevant information. Prices of assets change instantaneously to eliminate excess demand so that the world demand for each asset continuously equals its supply.

¹⁶Firms in the capital-supplying sector produce capital and rent it to firms in the goods-producing sectors.

$$B = B_H + B_F, \quad B^* = B_H^* + B_F^*, \quad (3.3)$$

$$V = q(K_H + K_F), \quad V^* = q^*(K_H^* + K_F^*), \quad (3.4)$$

where B and B^* denote bonds issued by domestic and foreign governments in terms of local consumption baskets, subscript H and F denote the ownership of assets, and V and V^* denote market values of locally-held equity claims on domestic and foreign capital stocks. The market values are simply the products of equity prices q and q^* , and capital stocks K and K^* respectively.

Households allocate their wealth among domestic and foreign assets to maximize expected returns on their asset holdings. This optimizing behavior is reflected in the following portfolio equilibrium conditions respectively¹⁷

$$\frac{\dot{q}}{q} + \frac{D}{qK} = r, \quad (3.5a)$$

$$\frac{\dot{q}^*}{q^*} + \frac{D^*}{q^*K^*} = r^*, \quad (3.5b)$$

where $\dot{q}/q$ and $\dot{q}^*/q^*$ denote rates of capital gains on equity holdings due to equity price changes, and D/qK and D^*/q^*K^* are rates of dividends paid by firms in the capital-supplying industry. The sum of the rate of capital gain and the rate of the dividend yield is the

¹⁷Two points in this statement should be noted. First, expected returns equal actual returns in this model because agents are assumed to possess perfect foresight. Second, the arbitrage conditions (3.5a) and (3.5b) are strong statements because they imply that bonds and equities are perfect substitutes. Although, this is not true for individual equities, it is approximately true if the comparison is made between bonds and a well-diversified portfolio of equities with a very small overall market risk premium.

instantaneous return on equity claims

Asset market equilibrium conditions (3.5a) and (3.5b) have three implications essential to international financial integration. First, investors in each economy continuously adjust their portfolio until expected returns on local bonds and equities are equalized. Second, investors will continuously move funds toward the asset with a higher expected real return until expected real returns obtainable from assets denominated in the domestic currency equal expected real returns from comparable assets denominated in the foreign currency plus the expected rate of depreciation of the domestic currency. Third, the domestic and foreign assets market equilibria are achieved simultaneously by international arbitrage.

4.2. Production of capital

The supply of equity claims depends on the stock of capital. In this section, the fundamental determinants for both investment in the capital stock and the value of equity claims are discussed in detail. The characterization of investment behavior is a direct extension of Hayashi (1982) and Murphy (1989).

Investment in each economy is carried out by competitive firms in the capital-supplying industry from which all firms in the goods-producing industries rent capital services. The supply of capital in each economy equals its demand at any point of time. The investment decision is therefore made by value-maximizing firms in the capital-supplying industry in a manner consistent with Tobin's Q theory (1969). The theory proposes that the rate of investment depends on Q , the ratio of the market value of an additional capital to its replacement cost. The investment decision also follows the cost-of-adjustment literature,

which says that the installation cost of capital is an increasing function of capital formation.¹⁸

Firms in the capital-supplying industry maximize the sum of discounted future cash flows

$$V(0) = \int_0^{\infty} D(t) e^{-\int_0^t r(s) ds} dt, \quad (3.6a)$$

$$V^*(0) = \int_0^{\infty} D^*(t) e^{-\int_0^t r^*(s) ds} dt, \quad (3.6b)$$

where $V(0)$ or $V^*(0)$ is the discounted present value of the expected future net income stream. The market price of equity claims in each economy therefore reflects the expected net future income stream. Since asset market arbitrage leads to the equalization of returns on bonds and equities in equilibrium, the interest return on bonds is the appropriate rate for discounting the future net income stream.

For simplicity, investment is assumed to be financed by new equity issues only.¹⁹ It follows that the future net income, or net cash flow, of the capital-supplying industry is all paid to holders of equity claims as dividends D and D^* . The dividend payment of each economy is defined as the total after-tax income from renting capital less total investment expenditure on inputs, which is formulated as

¹⁸Major contributions to Tobin's Q and the cost-of-investment literature include Lucas (1967), Gould (1968), Uzawa (1969), Mussa (1977), Hayashi (1982), and Abel and Blanchard (1983).

¹⁹The mix of financing schemes (i.e., financing through debt, new equity issues or retained earnings) will not significantly affect the analytical results of this model. However, the wealth accumulation of households will be affected since different financing schemes imply different distributions of net income of the capital-supplying sector at each period. For instance, investment financed by retained earnings implies that dividend payments will be lower

$$D = (1-\tau)(1-\delta)K - wL_K - I, \quad (3.7a)$$

$$D^* = (1-\tau^*)(1-\delta^*)K^* - w^*L_K^* - I^*, \quad (3.7b)$$

where

τ, τ^* = corporate tax rates that are proportional to rental revenue,²⁰

$wL_K, w^*L_K^*$ = expenditures on inputs of labor in the production of capital,

I, I^* = total expenditures on inputs of traded and nontraded goods;

δ, δ^* = rates of physical depreciation of capital stocks,

r, r^* = rental rates in terms of traded goods received by the capital-supplying sectors for providing capital equipment to the goods-producing sectors

The rental rate equals the rate of interest plus the rate of physical depreciation, $r = r + \delta$ and $r^* = r^* + \delta^*$. Assuming full deductibility of depreciation from taxable income, the taxable rental revenues are then rK and r^*K^* . For simplicity, the depreciation allowance per unit of investment for tax purpose equals the actual physical depreciation so that there is no need to consider the impact of their difference on investment. It is also assumed that there is no investment tax credit.

The third terms in (3.7a) and (3.7b) require further explanation. The cost of labor aside, total investment expenditures of individual economies on inputs of traded and nontraded goods in installing capital are assumed to be nonnegative and are given by

²⁰For simplicity, equations (3.7a) and (3.7b) assumes full deductibility of physical depreciation of capital stocks but zero deductibility of net investment expenditures from taxable income. The assumption does not affect the analytical results qualitatively given that net investment expenditures are less than fully deductible. If the capital-supplying sector is allowed to deduct fully its investment expenditures from taxable income, changes in the tax rate will not affect investment incentives. Also see Murphy (1989), footnote 16.

$$I = I_T + PI_N = J + P\varphi\left(\frac{J}{K}\right)J, \quad (3.8a)$$

$$I^* = I_T^* + P^*I_N^* = J^* + P^*\varphi^*\left(\frac{J^*}{K^*}\right)J^*, \quad (3.8b)$$

where I_T , I_T^* , PI_N and $P^*I_N^*$ are total investment expenditures on traded and nontraded goods, J and J^* are units of newly installed capital or gross capital formation, and J/K and J^*/K^* indicate rates of capital installation, which are the ratios of newly installed capital to the existing capital stocks.²¹

In order to install J units of capital stock, the capital-supplying sectors must first purchase $I_T = J$ and $I_T^* = J^*$ amounts of traded goods, which are then irreversibly transformed into capital stocks at an installation cost that absorbs $I_N = \varphi(J/K)J$ and $I_N^* = \varphi^*(J^*/K^*)J^*$ units of nontraded goods.²² Total domestic investment expenditures on traded and nontraded goods I and I^* differ from capital installations J and J^* because of the installation costs $\varphi(J/K)$ and $\varphi^*(J^*/K^*)$ required in the process of transforming traded goods into capital stocks. The assumption of symmetry implies that $\varphi = \varphi^*$. Equations (3.8a) and (3.8b) thus indicate the total investment expenditure on traded and nontraded goods to install J and J^* units of capital measured in terms of traded goods. Following Hayashi (1982), the installation cost is assumed to be an increasing and convex function of the rate of capital installation, i.e. $\varphi'(0) = 0$, $\varphi'(\bullet)$

²¹The rate of capital installation differs from the rate of capital accumulation by the rate of depreciation.

²²In this model, the cost of labor inputs is treated separately from the cost of goods inputs reflected in the adjustment-cost function. This treatment simplifies the model because it separates the labor cost, which is exogenous, from investment expenditures on goods as inputs, which are endogenous and need to be considered throughout the model. This treatment is consistent with the existing adjustment-cost literature.

> 0 and $\varphi''(\bullet) > 0$. This means that the installation cost per unit of capital will be greater, the greater the rate of capital installation

Capital stock accumulations over time are given by

$$\dot{K} = J - \delta K, \quad (3.9a)$$

$$\dot{K}^* = J^* - \delta^* K^*, \quad (3.9b)$$

where J and J^* , as defined in (3.8a) and (3.8b), represent gross newly installed capital stocks and δK and $\delta^* K^*$ are the amount of depreciation.

Firms in the capital-supplying sector of each economy maximize the objective functions (3.6a) and (3.6b) subject to (3.9a) and (3.9b), which means maximizing the discounted present values of shareholders' equity claims subject to the capital accumulation constraint. Substitution of (3.8a) and (3.8b) into (3.7a) and (3.7b) respectively, and then (3.7a) and (3.7b) into (3.6a) and (3.6b) respectively, gives the following Hamiltonian for the optimizing behavior of a representative firm at home:

$$H = \left\{ (1 - \tau)rK - wL_K - J \left[1 + P\varphi\left(\frac{J}{K}\right) \right] + q(J - \delta K) \right\} e^{-\rho t}, \quad (3.10a)$$

where $q(J - \delta K)$ is the value of net investment at each moment in time

The first-order conditions for maximization with respect to units of the newly installed

capital and the optimal accumulation of the capital stock yield the following:²³

$$\frac{\partial H}{\partial J} = q^{-1} - P \left[\varphi\left(\frac{J}{K}\right) + \varphi'\left(\frac{J}{K}\right) \frac{J}{K} \right] = 0 ,$$

$$q^{-1} = P \left[\varphi\left(\frac{J}{K}\right) + \varphi'\left(\frac{J}{K}\right) \frac{J}{K} \right] . \quad (3.11a)$$

$$\frac{\partial H}{\partial K} + d(q e^{-\rho t})/dt = \left[(1-\tau)r - \delta q + P \varphi'\left(\frac{J}{K}\right) \left(\frac{J}{K}\right)^2 + q - r q \right] e^{-\rho t} = 0 ,$$

$$q = q(r + \delta - (1-\tau)r - P \varphi'\left(\frac{J}{K}\right) \left(\frac{J}{K}\right)^2) . \quad (3.12a)$$

The optimization problem for a representative foreign firm parallels that of the domestic capital-supplying firms and thus yields analogous first order conditions:

$$q^*^{-1} = P^* \left[\varphi^*\left(\frac{J^*}{K^*}\right) + \varphi^{*'}\left(\frac{J^*}{K^*}\right) \frac{J^*}{K^*} \right] , \quad (3.11b)$$

$$q^* = q^*(r^* + \delta^*) - (1-\tau^*)r^* - P^* \varphi^{*'}\left(\frac{J^*}{K^*}\right) \left(\frac{J^*}{K^*}\right)^2 . \quad (3.12b)$$

The right-hand sides of (3.11a) and (3.11b) are marginal costs of producing additional

²³The first order condition with respect to labor will be ignored for the reason explained in footnote 16 above

units of capital in the two economies. The market values of capital, q and q^* , are determined by marginal values of additional units of capital. Optimizing firms will install capital as long as each dollar spent on new capital is expected to raise the market value of the firm by one dollar plus the marginal cost of installation. Thus, equations (3.11a) and (3.11b) imply that

$$\frac{J}{K} = h\left(\frac{q-1}{P}\right), \quad h\left(\frac{q-1}{P}\right) > 0, \quad h(1)=0, \quad (q-1) > 0, \quad (3.13a)$$

$$\frac{J^*}{K^*} = h^*\left(\frac{q^*-1}{P^*}\right), \quad h^*\left(\frac{q^*-1}{P^*}\right) > 0, \quad h^*(1)=0, \quad (q^*-1) > 0. \quad (3.13b)$$

Equations (3.13a) and (3.13b) mean that rates of capital installation, J/K and J^*/K^* , are positively related to expected returns on each dollar spent on the newly installed capital. The expected returns are reflected in the ratios of the marginal value of the newly installed capital to its replacement cost.²⁴ The $(q-1)/P$ and $(q^*-1)/P^*$ ratios are referred to as Q ratios.

Equations (3.12a) and (3.12b) indicate the optimal time paths for equity prices in each economy respectively. They are functions of the current market value of equity claims, the real interest rate, the cost of capital installation and the tax rate. The determination of the optimal time paths for equity prices will be discussed in detail later after all sectors in the two economies are considered.

²⁴In Tobin's Q theory, the investment decision is based on the ratio of the marginal value of an additional unit of capital to its replacement cost. However, the marginal value is not observable in the real world. Hayashi in his 1982 paper proves that the marginal value of a newly installed capital, under the assumptions of constant return to scale and perfect competition, equals the average value of all the existing capital stock, which is the market value of equity claims denoted by q .

5. Households

Infinitely-lived households make two distinct decisions. First, they choose a time path of consumption and savings that maximizes the discounted value of their lifetime utility. Then they choose a return-maximizing portfolio for their wealth held in forms of all four assets. The second maximizing decision is reflected in the asset market equilibrium conditions (3.5a) and (3.5b) in Section 4.1. This section will consider the first decision.

Households maximize the present discounted value of lifetime utility from their stream of consumption subject to an instantaneous wealth accumulation constraint:

$$\dot{W} = rW + (1-\tau)wL - C_T - PC_N, \quad (3.14a)$$

$$\text{where } W = B_H + EB_H^* + V_H + EV_H^*.$$

W is the total value of real wealth denominated in the consumption basket and held in forms of all four assets,²⁵ rW denotes the total return to assets,²⁶ $(1-\tau)wL$ denotes the wage income net of tax, and $C_T + PC_N$ is the total consumption expenditure of traded and nontraded goods.

The constrained maximization problem of domestic households is expressed in the

²⁵Conventional macroeconomic theory, according to the Ricardian Equivalence hypothesis, excludes interest payments on government bonds from the wealth of infinitely lived households because bonds are seen both as a promise of future interest payments from the government and as an implicit promise of future taxes needed to pay the interest. They represent both an asset and a liability of the same value. The private decision concerning asset allocation and accumulation should therefore be unaffected by bonds. However, in an open-economy model, interest payments to foreign holders will be financed by taxation on domestic residents, and vice versa. If tax rates of the two economies are different, bonds will affect the accumulation of private wealth.

²⁶The rate of return to the domestic households for holding foreign equities should equal r^* . However, when the effect of the rate of real depreciation is taken into account, the relevant rates of returns that determine portfolio choice between foreign and domestic equities are r and r^* where r and r^* are measured in terms of consumption baskets of the two economies respectively.

following present-value Hamiltonian

$$H = [U(C_T, C_N) + \lambda(rW + (1-\tau)wL - C_T - PC_N)] e^{-\xi t},$$

where λ denotes the marginal utility of the accumulated wealth of households or the intertemporal rate of substitution between consumption today and tomorrow, and ξ denotes the rate of pure time preference consumers use to discount their continuous stream of income in the future. The constrained maximization problem of foreign households can be expressed using a similar Hamiltonian.

The first-order partial derivatives for maximization with respect to the consumption of traded and nontraded goods, and the optimal path of wealth accumulation give the following relationships for each economy:

$$\frac{\partial H}{\partial C_T} = U_T(C_T, C_N) - \lambda = 0, \quad U_T = \lambda. \quad (3.16a)$$

$$\frac{\partial H}{\partial C_N} = U_N(C_T, C_N) - P\lambda = 0, \quad U_N = P\lambda.$$

$$\frac{\partial H}{\partial W} + d(\lambda e^{-\xi t})/dt = (r\lambda - \xi\lambda + \lambda)e^{-\xi t} = 0,$$

$$\dot{\lambda} = (\xi - r)\lambda. \quad (3.17a)$$

$$\frac{\partial H^*}{\partial C_T^*} = U_T^*(C_T^*, C_N^*) - \lambda^* = 0, \quad U_T^* = \lambda^*. \quad (3.16b)$$

$$\frac{\partial H^*}{\partial C_N^*} = U_N^*(C_T^*, C_N^*) - P\lambda^* = 0, \quad U_N^* = P\lambda^*.$$

$$\frac{\partial H^*}{\partial W^*} + d(\lambda^* e^{-\xi^* t})/dt = (r^* \lambda^* - \xi^* \lambda^* + \lambda^*) e^{-\xi^* t} = 0,$$

$$\dot{\lambda}^* = (\xi^* - r^*) \lambda^*. \quad (3.17b)$$

Equations (3.16a) to (3.17b) have the following implications. First, in an economy with infinitely-lived households who maximize their discounted value of lifetime utility, the representative consumer's time profile of optimal consumption depends on the relative values of the real rate of interest and the rate of time preference. Assuming symmetry, the two economies' rates of time preference are identical, and their intertemporal substitutions between consumption and saving are also the same.

Second, the consumer's time profile of optimal consumption also depends on the relative price of nontraded goods over time. As explained in Assumption 6, the real interest rate differential between the domestic and foreign economies arises to the extent that the relative prices of nontraded goods change over time. The distinction between traded and nontraded goods also implies that r and r^* do not necessarily equal ξ and ξ^* (which are equal and constant) as the relative prices of nontraded goods, P and P^* , change over time before reaching their respective long-run equilibrium levels. For instance, a falling relative price of

nontraded goods in an economy, which implies an expected real depreciation, suggests that a unit of consumption borrowed today costs more to repay tomorrow. Accordingly, the domestic real interest rate measured using the domestic consumption price index exceeds the foreign real interest rate. Due to the existence of nontraded goods, $r \neq \xi$, $r^* \neq \xi^*$ and $\xi = \xi^*$ along the adjustment path toward equilibrium.²⁷

Third, in steady state, rates of changes in the marginal rate of substitution $\dot{\lambda}$ and $\dot{\lambda}^*$ are equal to zero. All markets are in equilibrium so that the relative prices of nontraded goods, therefore the real exchange rate, do not change. The necessary and sufficient condition for steady-state equations (3.17a) and (3.17b) to hold requires that $\xi = r = \xi^* = r^*$. Thus, in the steady state, the real interest rate is predetermined at the rate of pure time preference. The equalization among real rates of interest and rates of time preference of the two economies reflects the fact that, in the steady state, the relative prices of nontraded goods of both economies equal their respective long-run equilibrium levels and $\dot{E} = 0$.

6. Government Expenditure

Governments of both economies are assumed to finance their expenditures on goods and interest payments to bond holders through taxation and borrowing on international markets.²⁸ Let G_T , G_T^* , G_N and G_N^* be the domestic and foreign government expenditures

²⁷See Dornbusch (1988), Section 2, Chapter 16 (originally published in *Journal of Political Economy*, 1983) for detailed discussions on the consumers' optimal time profile as being a function of both the ratio of the real rate of interest to the rate of time preference and the relative price of nontraded goods. Other references include Buter (1981), Obstfeld (1981b), and Lipton and Sachs (1983).

²⁸Each economy is assumed to have a proportional tax rate on income and corporate profit.

on traded and nontraded goods respectively. Government debts of the two economies face the following accumulation constraints:

$$\dot{B} = r(B_H + B_F) + (G_T + PG_N) - \tau(rK + wL) , \quad (3.18a)$$

$$\dot{B}^* = r^*(B_H^* + B_F^*) + (G_T^* + PG_N^*) - \tau^*(r^*K^* + w^*L^*) . \quad (3.18b)$$

7. Equilibria of Domestic and World Goods Markets

In Sections 3-6, the supply and demand for traded and nontraded goods (from the capital-supplying industry, households and the government) are discussed respectively. To close the model, all prices of goods are determined endogenously and are assumed to adjust instantaneously so that goods market equilibrium conditions always hold. These conditions determine the relative prices of nontraded goods in the two economies.

The nontraded good market equilibrium conditions are given by:

$$Y_N(P, K) = C_N(P) + I_N((q-1)/P, K) + G_N , \quad (3.19a)$$

$$Y_N^*(P^*, K^*) = C_N^*(P^*) + I_N^*((q^*-1)/P^*, K^*) + G_N^* , \quad (3.19b)$$

where total investment expenditures on nontraded goods I_N^* and I_N are derived from (3.8a), (3.8b) (3.13a) and (3.13b), and government expenditures on nontraded goods are exogenously given. Given the nontraded goods market equilibrium, implicit functions of relative prices of nontraded goods can be derived from equations (3.19a) and (3.19b):

$$P = v(q, K, E, G_N), \quad v_1 > 0, v_2 > 0, v_3 < 0, v_4 > 0 \quad (3.20a)$$

$$P^* = v^*(q^*, K^*, E, G_N^*), \quad v_1^* > 0, v_2^* > 0, v_3^* > 0, v_4^* > 0 \quad (3.20b)$$

Fluctuations of the relative prices P and P^* will reflect real disturbances in domestic and foreign economies, such as government spending and investment ²⁹

A higher equity price, q , indicates a higher current marginal value of capital as well as an expected higher income for firms in the capital-supplying industry. This encourages capital investment, which in turn creates an excess demand for nontraded goods. The relative price of nontraded goods therefore needs to rise to clear the market.

An increase in the capital stock reduces output in the relatively labor-intensive nontraded sector according to the Rybczynski effect. As a result, a rise in the relative price of nontraded goods is required to eliminate the excess demand.

The domestic relative price of nontraded goods is negatively related to the real exchange rate. Since the exchange rate reflects fundamentals in both economies, if the foreign investment or government expenditure rises, there will be an excess demand for nontraded goods in the foreign economy that will require a rise in the foreign relative price of nontraded goods. *Ceteris paribus*, there will be an increase in the relative price between the two economies, or a depreciation in the real exchange rate, which implies that the domestic relative price of nontraded goods in terms of traded goods will be lower.

²⁹Since the effects of consumption on the relative price of nontraded goods are similar to that of investment and since the model focuses primarily on the capital market, consumption will be omitted from the final analytical framework to simplify the model.

An increase in government spending on nontraded goods creates an excess demand for nontraded goods. P needs to increase to eliminate this excess demand.

The preceding arguments are analogous for the foreign economy except that changes in the real exchange rate will affect the foreign relative price in the opposite way.

The price of traded goods is determined by equilibrium in the world market for traded goods:

$$NX = [Y_T(P, K) - D_T(P)] + [r^* E(B_H^* + q^* K_H^*) - r(B_F + qK_F)] , \quad (3.21a)$$

$$NX^* = [Y_T^*(P^*, K^*) - D_T^*(P^*)] + [r \frac{1}{E}(B_F + qK_F) - r^*(B_H^* + q^* K_H^*)] , \quad (3.21b)$$

$$NX + NX^* = 0, \quad Y_T + Y_T^* = D_T + D_T^*, \quad (3.22)$$

where NX and NX^* denote the domestic and foreign current account positions respectively.

In equations (3.21a) or (3.21b), the first square bracket on the right-hand side indicates the trade balance of each economy. The second square bracket indicates net payments to foreign assets measured in the domestic consumption basket. r and r^* are returns on bonds, which equal returns on equity claims due to asset market arbitrage.

Equation (3.22) indicates that one economy's current account deficit must equal another economy's current account surplus, and the aggregate world supply of traded goods must equal the aggregate demand for traded goods.

8. Solution of the Model

In order to examine the joint reactions of equity markets, capital accumulations and the exchange rate of the two economies in response to macroeconomic innovations in either or both economies, the next step is to obtain dynamic representations of these variables as functions of fundamentals that directly or indirectly affect the current and expected equity returns in both economies

The dynamics of equity prices and capital accumulations are obtained by substituting the relative price functions for nontraded goods $P = v(\cdot)$ and $P^* = v^*(\cdot)$ given by (3.20a) and (3.20b) into (3.12a), (3.12b), (3.9a) and (3.9b).

$$\begin{aligned}
 q &= (r + \delta)q - (1 - \tau)r - v(\cdot)\varphi \left[h \left(\frac{q-1}{v(\cdot)} \right) \right] \left[h \left(\frac{q-1}{v(\cdot)} \right) \right]^2 \\
 &= a(q, v(q, K, E, G_N), \tau, r) \\
 &= \alpha(q, K, E, G_N, \tau, r) ,
 \end{aligned} \tag{3.23a}$$

$$\begin{aligned}
 q^* &= (r^* + \delta^*)q^* - (1 - \tau^*)r^* - v^*(\cdot)\varphi^* \left[h^* \left(\frac{q^*-1}{v^*(\cdot)} \right) \right] \left[h^* \left(\frac{q^*-1}{v^*(\cdot)} \right) \right]^2 \\
 &= a^*(q^*, v^*(q^*, K^*, E, G_N^*), \tau^*, r^*) \\
 &= \alpha^*(q^*, K^*, E, G_N^*, \tau^*, r^*) .
 \end{aligned} \tag{3.23b}$$

$$\begin{aligned}
\dot{K} &= \left[h \left(\frac{q-1}{v(\cdot)} \right) - \delta \right] K \\
&= b \left(\frac{q-1}{v(\cdot)}, K \right) = \beta(q, K, E, G_N) .
\end{aligned} \tag{3.24a}$$

$$\begin{aligned}
\dot{K}^* &= \left[h^* \left(\frac{q^*-1}{v^*(\cdot)} \right) - \delta^* \right] K^* \\
&= b^* \left(\frac{q^*-1}{v^*(\cdot)}, K^* \right) = \beta^*(q^*, K^*, E, G_N^*) .
\end{aligned} \tag{3.24b}$$

Taking the Taylor expansion of equations (3.23a), (3.23b), (3.24a) and (3.24b) around the steady-state equilibrium and dropping all terms of order higher than one yields the following linear approximation of the system:

$$q = \alpha_1(q - \bar{q}) + \alpha_2(K - \bar{K}) + \alpha_3(E - \bar{E}) + \alpha_4(G_N - \bar{G}_N) + \alpha_5(\tau - \bar{\tau}) + \alpha_6(r - \bar{r}), \tag{3.25a}$$

$$q^* = \alpha_1^*(q^* - \bar{q}^*) + \alpha_2^*(K^* - \bar{K}^*) + \alpha_3^*(E - \bar{E}) + \alpha_4^*(G_N^* - \bar{G}_N^*) + \alpha_5^*(\tau^* - \bar{\tau}^*) + \alpha_6^*(r^* - \bar{r}^*), \tag{3.25b}$$

$$\dot{K} = \beta_1(q - \bar{q}) + \beta_2(K - \bar{K}) + \beta_3(E - \bar{E}) + \beta_4(G_N - \bar{G}_N), \tag{3.26a}$$

$$\dot{K}^* = \beta_1^*(q^* - \bar{q}^*) + \beta_2^*(K^* - \bar{K}^*) + \beta_3^*(E - \bar{E}) + \beta_4^*(G_N^* - \bar{G}_N^*) . \tag{3.26b}$$

where $\dot{q}$ and $\dot{K}$ are the time derivatives of the equity price and the capital stock

Coefficients α 's in equation (3.25a), which indicate the effects of underlying economic variables q , K , E , G_N , τ and r on the time path of the domestic equity price, can also be obtained respectively from the Taylor expansion of (3.23a) as follows

$$\alpha_1 = a_1 + a_2 v_1 = (r + \delta) - \varphi' h^2 v_1 - (h^2 \varphi'' + \varphi' 2h) h' (P - q v_1) / P > 0 ,$$

$$\alpha_2 = a_2 v_2 = -\varphi' h^2 v_2 + (h^2 \varphi'' + \varphi' 2h) h' q v_2 / P > 0 ,$$

$$\alpha_3 = a_2 v_3 = -\varphi' h^2 v_3 - (h^2 \varphi'' + \varphi' 2h) h' (q' P - q v_3) / P < 0 , \quad v_3 < 0 ,$$

$$\alpha_4 = a_2 v_4 = -\varphi' h^2 v_4 + (h^2 \varphi'' + \varphi' 2h) h' q v_4 / P > 0 , \quad (3.27)$$

$$\alpha_5 = a_3 = r > 0 ,$$

$$\alpha_6 = a_4 = (q + \tau - 1) > 0 .$$

For simplicity, v_i denotes the partial derivative of the domestic relative price of nontraded goods with respect to the i th variable in the function $P = v(q, K, E, G_N)$, φ is used instead of $\varphi(J/K)$, which is the functional form for the cost of capital installation, and h is used instead of $J/K = h[(q-1)/P]$, which is the rate of capital installation

The expected return of the capital-supplying sector may increase because of two factors in the model. First, it could be the result of an increase in the current marginal value of capital due to a decrease in the capital stock. Second, it could be the result of a macroeconomic innovation that reduces the cost of capital installation. On both accounts, q

2

PM-1 3 1/2" x 4" PHOTOGRAPHIC MICROCOPY TARGET
NBS 1010a ANSI/ISO #2 EQUIVALENT

PRECISIONSM RESOLUTION TARGETS

will be higher. The asset market equilibrium condition (3.5) then requires an upward movement of $\dot{q}$ given other variables. α_1 is therefore positive.³⁰

A larger capital stock has a positive effect on the price of nontraded goods, which in turn reduces the Q ratio, through two channels. An increase in the capital stock reduces output in the relatively labor-intensive nontraded sector according to the Rybczynski effect. In addition, the demand for nontraded goods rises in the process of installing capital. As a result, the relative price of nontraded goods has to rise to eliminate the excess demand. The higher relative price of nontraded goods increases the installation cost according to equation (3.8a) and lowers expected returns $(q-1)/P$, which in turn reduces the demand for equities. To maintain the asset market equilibrium condition (3.5), the lower expected income (reflected in expected dividends, D) requires that either the actual market value of equity claims fall short of its long-run level at $\dot{q} = 0$, or $\dot{q}$ moves upward over time. It follows that α_2 is positive.

Conversely, a real depreciation lowers the domestic relative price of nontraded goods in terms of traded goods, therefore decreases the cost of capital installation. This will in turn produce an effect on $\dot{q}$ that is opposite to the effect of an increase in capital investment. Accordingly, α_3 is negative.

Higher government spending or a higher corporate tax rate reduces expected returns on capital either by raising the demand for nontraded goods, therefore the relative price of nontraded goods, or by taking more from corporate earnings. As explained earlier, the current

³⁰When q increases, $\dot{q}$ is required to increase too. This result may not seem intuitive. It will be proved later that the solution of the model is saddle-path stable. The mathematics, illustrations and economic intuition will be discussed in detail in Section 8.1.

level of q has to fall below $\bar{q}$ or $\dot{q} < 0$ to maintain the asset market arbitrage condition. α_4 and α_5 are therefore both positive

Given other variables, an increase in the real interest rate requires either the actual market value of equity claims fall short of its long-run level at $\dot{q} = 0$, or $\dot{q}$ moves upward in order to maintain the asset market equilibrium condition. Thus, α_6 is positive too.

Directions and magnitudes of the effects on the domestic capital accumulation produced by changes in q , K , E and G_N are reflected respectively in coefficients β 's in (3.26a), which are obtained from the Taylor expansion of equation (3.24a):

$$\begin{aligned}\beta_1 &= b_1 v_1 = Kh'(P - v_1 q)/P^2 > 0, \\ \beta_2 &= b_2 + b_1 v_2 = (h - \delta) - Kh'v_2 q/P^2 < 0, \\ \beta_3 &= b_1 v_3 = Kh'(q'P + v_3 q)/P^2 > 0, \\ \beta_4 &= b_1 v_4 = -Kh'v_4 q/P^2 < 0.\end{aligned}\tag{3.28}$$

As discussed previously, the optimal capital investment is determined based on the expected returns on capital, which are defined as $(q-1)/P$ in this model. Therefore, an essential point implied by (3.28) is that any economic innovation that affects the ratio will affect capital accumulation.

β_1 is positive because a higher equity price indicates a higher market value of capital, which in turn stimulates investment.

An increasing capital stock creates an excess demand for nontraded goods, thereby

pushing up the relative price of nontraded goods and the cost of capital installation. Meanwhile, with a larger capital stock, q falls due to diminishing returns. Therefore, the ratio $(q-1)/P$, or the return to producing capital declines on both accounts. From equation (3.13a), a lower $(q-1)/P$ reduces the rate of capital formation over time. Accordingly, β_2 is negative.

β_3 is positive because a real depreciation indicates a lower relative price of nontraded goods, therefore a lower cost of capital and higher expected profit, which affects the growth of capital positively.

An increase in government spending on nontraded goods has a positive effect on the relative price of nontraded goods and a negative effect on the expected return on capital. It therefore discourages investment, which means that β_4 is negative. Expansionary fiscal policy crowds out private investment in a way different from those in the existing literature. In many macroeconomic models, the crowding-out takes place either due to the negative effect of a higher interest rate on private investment in a closed economy, or because of the appreciating effect of a higher domestic interest rate on the exchange rate that in turn shrinks the traded goods sector. In the present context, the driving force of the crowding-out effect is the higher relative price of nontraded goods that reduces the expected return to capital. The lower expected return in turn discourages investment.

Given the assumption of symmetry, α 's and β 's in equations (3.25a) and (3.26a) and the corresponding α 's and β 's in (3.25b) and (3.26b) are the same both in magnitude and sign, except that the real depreciation will affect the two economies by magnitudes that are equal in absolute values, but opposite in sign.

Consider next the dynamic path of the real exchange rate. The real exchange rate is

related to the relative prices of nontraded goods between the two economies. Innovations in fundamentals that affect the current and future relative economic conditions produce deviations of the current relative prices of nontraded goods from their steady-state values. This in turn creates a divergence of the current real exchange rate from its steady-state value. The dynamic process may be obtained by first rewriting equations (3.2)' as:

$$\dot{E} = -\theta (E - \bar{E}), \quad E - \bar{E} = -\eta [(P - \bar{P}) - (P^* - \bar{P}^*)] , \quad (3.29)$$

where $\eta > 0$ is the weight of nontraded goods in the price index.

If the current domestic (foreign) relative price of nontraded goods is higher (lower) than its equilibrium level, the price differential between the two economies will be greater and the current exchange rate falls short of its equilibrium level ($E < \bar{E}$). There will be an expected real depreciation.³¹

The next step is to find the links between the dynamic path of the real exchange rate and the relative economic fundamentals of the two economies. Total differentiation of the price functions (3.20a) and (3.20b) gives:³²

³¹It is necessary here to restate the relationship between equations (3.2) and (3.2'), which reflect uncovered real interest parity, and equation (3.29). Given foreign fundamentals, a higher current domestic relative price of nontraded goods than its equilibrium level suggests two things: an overvalued domestic currency, and a higher domestic real interest rate than the foreign real interest measured in terms of consumer price indexes. If deviations of fundamental variables from their respective equilibrium levels cause $P > \bar{P}$, P is expected to fall, therefore the real exchange rate is expected to depreciate. This is exactly what is reflected in the uncovered interest parity condition.

³²The total differentiations approximate variations in the functional forms of the relative prices of nontraded goods (3.20a) and (3.20b) in a sufficiently small neighborhood of the equilibrium points to obtain local stability conditions.

$$P - \bar{P} = v_1(q - \bar{q}) + v_2(K - \bar{K}) + v_3(E - \bar{E}) + v_4(G_N - \bar{G}_N),$$

$$P^* - \bar{P}^* = v_1^*(q^* - \bar{q}^*) + v_2^*(K^* - \bar{K}^*) + v_3^*(E - \bar{E}) + v_4^*(G_N^* - \bar{G}_N^*),$$

where v 's are as given in (3.20a) and (3.20b). Substitution of $P - \bar{P}$ and $P^* - \bar{P}^*$ into (3.29) gives:

$$\begin{aligned} \dot{E} = & \frac{\theta \eta v_1}{1 + 2\eta v_3} [(q - \bar{q}) - (q^* - \bar{q}^*)] + \frac{\theta \eta v_2}{1 + 2\eta v_3} [(K - \bar{K}) - (K^* - \bar{K}^*)] \\ & + \frac{\theta \eta v_4}{1 + 2\eta v_3} [(G_N - \bar{G}_N) - (G_N^* - \bar{G}_N^*)], \end{aligned} \quad (3.30)$$

where $v_3 < 0$ and $(1 + 2\eta v_3) > 0$.

Equation (3.30) indicates that the dynamic path of the real exchange rate is based on the relative corresponding underlying variables of the two economies. If any two corresponding underlying variables do not change proportionally, the difference between the relative prices of nontraded goods rises or falls, forcing the adjustment of the real exchange rate. For instance, a greater differential between the domestic and foreign capital stocks or government expenditures increases the differential between their relative prices of nontraded goods. According to equation (3.29), the current real exchange rate falls below its steady-state level, or is over-appreciated, and is therefore expected to rise, or to depreciate.

Finally, the dynamics of the complete model are described by five differential

equations (3.25a), (3.25b), (3.26a), (3.26b) and (3.30). The endogenous variables of the model are q , q^* , K , K^* and E . The exogenous variables are G_N , G_N^* , τ , τ^* , r and r^* . The model links the optimal paths of equity prices, capital accumulations and the real exchange rate to economic fundamentals that affect expected returns on capital and therefore the demand for equity claims.

8.1. Steady state

The steady-state values of equity prices, capital stocks and the real exchange rate are obtained at $\dot{q} = \dot{q}^* = \dot{K} = \dot{K}^* = \dot{E} = 0$. As required by the consumer's optimization problem, $\bar{r} = \bar{\xi} = \bar{r}^* = \bar{\xi}^*$ is also achieved. The steady-state real exchange rate is linked to all real factors in the model that affect the relative prices of nontraded goods. The steady-state $\bar{q}$, $\bar{K}$, $\bar{q}^*$, $\bar{K}^*$, and $\bar{E}$ that satisfy $\dot{q} = \dot{q}^* = \dot{K} = \dot{K}^* = \dot{E} = 0$ are explicitly derived in Appendix A.

8.2. Dynamics

The dynamics of the model represented by five differential equations are complicated to solve. To overcome this difficulty, a procedure introduced by Aoki (1981) will be employed in the dynamic analysis in order to make the model tractable.³³

Aoki's method decouples the vectors of variables of the two economies (x, x^*) into (x^d, x^a) , where $x^a = (x+x^*)/2$ is the world average and $x^d = (x-x^*)$ is the world difference. This technique is a convenient tool for dynamic analysis. More importantly, it also has economic

³³The technique is described in Chapters 5, 12 and 13 of Aoki (1981). Applications of the method can be found in Turnovsky (1986a), Ambler (1989), and Bhandari and Genberg (1989).

implications. It is conventional wisdom that some economic variables, such as demand and prices, may vary due to changes in either the average or the relative values of the underlying fundamentals of the two economies, while other variables, such as the (real or nominal) exchange rate, are determined by relative economic fundamentals only

Besides, innovations in fundamentals that affect both economies by approximately the same magnitude but in the opposite directions affect the world difference but leave the average unchanged, that is.

$$\text{if } \Delta x = -\Delta x^*, \text{ where } \Delta x \neq 0, \quad \Delta x^* \neq 0, \quad \Delta x = x - \bar{x},$$

$$\Delta x^a = 0, \quad \Delta x^d \neq 0. \quad (3.31)$$

In contrast, fundamental innovations that change both economies by the same magnitude and in the same direction change the world average, but leave the difference unchanged, that is.

$$\text{if } \Delta x = \Delta x^*, \text{ where } \Delta x \neq 0, \quad \Delta x^* \neq 0, \quad \Delta x = x - \bar{x},$$

$$\Delta x^a \neq 0, \quad \Delta x^d = 0. \quad (3.32)$$

Innovations that affect one or both economies in a way other than (3.31) and (3.32) will change both x^a and x^d . Therefore, the Aoki technique may help us to distinguish effects of innovations common to both economies from effects of innovations differing for different economies. This distinction in turn enables us to investigate the impacts of macroeconomic policies in various situations.

Finally, this technique may produce useful inferences about the extent to which world equity markets are correlated. It may also suggest how responsive each equity market is to economic innovations in another economy. For instance, if the world equity price difference remains unchanged in response to an innovation in one economy, it indicates an instantaneous transmission of the innovation and the contemporaneous comovement of equity prices across economies. However, if the equity price difference changes immediately after the innovation, the change may be attributable to either simultaneous but different reactions from the two equity markets, or a lagged response of one equity market relative to the other. If the analytical result shows that the difference diminishes and gradually disappears over time, it suggests that the two equity markets have a linear cointegrating relationship.³⁴

8.2.1. Average System

The world average system consists of two dynamic equations, $\dot{q}^*$ and $\dot{K}^*$, with all underlying variables being averages of the corresponding variables of the two economies. $\dot{q}^*$ is obtained by multiplying the sum of equations (3.25a) and (3.25b) by one half, and $\dot{K}^*$ is obtained in the same way from (3.26a) and (3.26b). The summation is justified by the fact that the economic activities and equity markets of the two economies are linked by trade and the exchange rate in this model. Changes in q , q^* , K and K^* are functions of the aggregate underlying variables of the two economies.³⁵ The linearization of the differential-equation

³⁴For the time series concept of cointegration, see Chapter II, Section 3.3 for brief introduction and Chapter V, Section 2.3 for a test procedure.

³⁵See Appendix A for the derivation.

system about its long-run equilibrium should therefore be viewed as a linearization about the world aggregate equilibrium.

The average subsystem is given as

$$I\mu^a = Av^a + B\kappa^a, \quad (3.33)$$

where I is a 2×2 identity matrix, A is a 2×2 coefficient matrix for partial derivatives with respect to deviations of q and K from their long-run equilibrium values, B is a coefficient matrix of exogenous variables and μ^a , v^a , κ^a are defined as:

$$\mu^a = \begin{bmatrix} \dot{q}^a \\ \dot{K}^a \end{bmatrix}, \quad v^a = \begin{bmatrix} q^a - \bar{q}^a \\ K^a - \bar{K}^a \end{bmatrix}, \quad \kappa^a = \begin{bmatrix} G_N^a - \bar{G}_N^a \\ \tau^a - \bar{\tau}^a \\ r^a - \bar{r}^a \end{bmatrix},$$

$$I = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}, \quad A = \begin{bmatrix} a_1 + a_2 v_1 & a_2 v_2 \\ b_1 v_1 & b_2 + b_1 v_2 \end{bmatrix}, \quad B = \begin{bmatrix} a_2 v_4 & a_3 & a_4 \\ b_1 v_4 & 0 & 0 \end{bmatrix},$$

where $(b_2 + b_1 v_2) < 0$, $b_1 v_4 < 0$. All elements in matrix A and matrix B are as given in (3.27) and (3.28). The world average system does not include the dynamic path of the real exchange rate since it is determined only by the relative fundamentals of the two economies.

The characteristic equation of this subsystem is given as:

$$[\gamma \ I - A] = \begin{bmatrix} \gamma - a_1 - a_2 v_1 & -a_2 v_2 \\ -b_1 v_1 & \gamma - b_2 - b_1 v_2 \end{bmatrix} \quad (3.34)$$

$$= \gamma^2 - [(a_1 + a_2 v_1) - (b_2 + b_1 v_2)]\gamma + [(a_1 + a_2 v_1)(b_2 + b_1 v_2) - (b_1 v_1)(a_2 v_2)] = 0.$$

A saddlepoint stable equilibrium requires that the determinant of A be negative and that the eigenvalues of the dynamics have opposite signs. These conditions are satisfied. The determinant of A is derived as $-(a_1 + a_2 v_1)(b_2 + b_1 v_2) - b_1 v_1 a_2 v_2$, which is unambiguously negative. Since the determinant of A is the product of the characteristic roots of the differential equation system, the system must possess one positive root and one negative root. Let $\gamma_1 < 0 < \gamma_2$. Thus saddlepoint stability exists irrespective of whether the trace of A is positive or negative.

The complementary functions for the average differential-equation system (3.33) are given by:³⁶

$$q^a = \bar{q}^a + \frac{a_2 v_2}{\gamma_1 - a_1 - a_2 v_1} X_1 e^{\gamma_1 t} + \frac{a_2 v_2}{\gamma_2 - a_1 - a_2 v_1} X_2 e^{\gamma_2 t}, \quad (3.35)$$

$$K^a = \bar{K}^a + X_1 e^{\gamma_1 t} + X_2 e^{\gamma_2 t}, \quad (3.36)$$

$$\text{where } \frac{a_2 v_2}{\gamma_1 - a_1 - a_2 v_1} < 0, \quad \frac{a_2 v_2}{\gamma_2 - a_1 - a_2 v_1} > 0, \quad \gamma_1 < 0, \quad \gamma_2 > 0,$$

where arbitrary constants X_1 and X_2 can be determined from the initial conditions.

³⁶See Chiang (1984), pp 610-614 for a technical explanation.

Since the differential-equation system contains both a negative root γ_1 and a positive root γ_2 , both stable and unstable dynamics exist. However, the jump variable q^* responds immediately to a shock to keep the adjustment always on the stable saddlepoint path, along which the capital stock adjusts gradually

To obtain the solution for the saddlepoint path, drop the term associated with the positive root in (3.35) and (3.36), and then substitute (3.36) into (3.35) for X_1 to obtain

$$(q^* - \bar{q}^*) = \frac{a_2 v_2}{\gamma_1 - a_1 - a_2 v_1} (K^* - \bar{K}^*) < 0, \quad \gamma_1 < 0. \quad (3.37)$$

The relationship shows that q^* and K^* will move in opposite directions along the stable adjustment path toward equilibrium.

The two-dimensional average system is diagrammatically presented in Figure 3.1

Slopes of schedules $\dot{q}^* = 0$ and $\dot{K}^* = 0$ are given by:

$$\left. \frac{(q^* - \bar{q}^*)}{(K^* - \bar{K}^*)} \right|_{q^*=0} = - \frac{a_2 v_2}{a_1 + a_2 v_1} < 0, \quad a_2 v_2 > 0, \quad a_1 + a_2 v_1 > 0,$$

$$\left. \frac{(q^* - \bar{q}^*)}{(K^* - \bar{K}^*)} \right|_{K^*=0} = - \frac{b_2 + b_1 v_2}{b_1 v_1} > 0, \quad b_2 + b_1 v_2 < 0, \quad b_1 v_1 > 0.$$

The $\dot{q}^* = 0$ schedule is downward sloping since the marginal product of capital declines as the capital stock increases. The $\dot{K}^* = 0$ schedule is upward sloping because a rise

Figure 3.1: Capital Accumulation and Equity Market Equilibrium

in the capital stock, which implies a greater demand for nontraded goods, raises the relative price of nontraded goods. This in turn increases the cost of capital installation and reduces the net return from investment, $(q-1)/P$. It therefore requires an increase in q to maintain a zero rate of capital accumulation.

Equation (3.37) indicates that the saddlepoint stable adjustment path ss' is negatively sloping. It also implies that the saddlepoint path ss' is flatter than the $\dot{q}^* = 0$ schedule since

$$\left| \frac{a_2 v_2}{\gamma_1 - a_1 - a_2 v_1} \right| < \left| \frac{a_2 v_2}{a_1 + a_2 v_1} \right|, \quad \gamma_1 < 0, \quad (3.38)$$

where the left hand side is the slope of the saddlepoint path ss' and the right hand side is the slope of the $\dot{q}^* = 0$ schedule. At point A in Figure 3.1, the equilibrium conditions for the equity market and capital accumulation are simultaneously satisfied.

Next, consider how innovations affect the world average system. Assuming the world economy is initially in steady state with $q_0^* = \bar{q}_0^*$ and $K_0^* = \bar{K}_0^*$, the initial values of the system at $t = 0$ can be obtained from (3.35) and (3.36).

$$q_0^* = \frac{a_2 v_2}{\gamma_1 - a_1 - a_2 v_1} X_1, \quad (3.39)$$

$$K_0^* = X_1. \quad (3.40)$$

After an unanticipated innovation takes place at $t \geq 0$, which means $\kappa^* \neq 0$, the

disturbed world average will converge monotonically, at a rate γ_1 , to a new equilibrium

$$q_t^a = \bar{q}_t^a + \frac{a_2 v_2}{\gamma_1 - a_1 - a_2 v_1} X_1 e^{\gamma_1 t} + \frac{a_2 v_2}{\gamma_2 - a_1 - a_2 v_1} X_2 e^{\gamma_2 t}, \quad (3.41)$$

$$K_t^a = \bar{K}_t^a + X_1 e^{\gamma_1 t} + X_2 e^{\gamma_2 t}, \quad (3.42)$$

$$\text{where } \bar{q}_t^a = \bar{q}_0^a + \Delta \bar{q}^a, \quad \bar{K}_t^a = \bar{K}_0^a + \Delta \bar{K}^a, \quad (3.43)$$

$$\Delta \bar{q}^a = (\bar{q}_t^a - \bar{q}_0^a), \quad \Delta \bar{K}^a = (\bar{K}_t^a - \bar{K}_0^a).$$

where $\bar{q}^a$ and $\bar{K}^a$ are particular integrals for the differential-equation system (3.33), which can be written in matrix form as $v^a = -(A^{-1}B)\kappa^a$. They represent the new steady-state equity price and capital stock that differ from the initial steady-state by $\Delta \bar{q}^a = \bar{q}_t^a - \bar{q}_0^a$ and $\Delta \bar{K}^a = \bar{K}_t^a - \bar{K}_0^a$. Their explicit expressions can be derived if the exact shock to the economy is known. For example, if the shock to the world averages comes from higher government expenditures on nontraded goods, the particular integral $v^a = -(A^{-1}B)\kappa^a$ will be $[\bar{q}_t^a, \bar{K}_t^a]' = -(A^{-1}B)[\Delta G_N^a, 0]'$.

The adjustment path of the world average equity price and capital stock to an anticipated innovation announced at time t and effective at some future time T can also be obtained from (3.35), (3.36) and (3.43) as follows:¹⁷

for $0 \leq t < T$,

¹⁷Turnovsky (1986a) uses a similar method to determine the dynamic adjustment path of a standard two-economy model

$$q_t^a = \bar{q}_0^a + \frac{a_2 v_2}{\gamma_1 - a_1 - a_2 v_1} X_1 e^{\gamma_1 t} + \frac{a_2 v_2}{\gamma_2 - a_1 - a_2 v_1} X_2 e^{\gamma_2 t}, \quad (3.44)$$

$$K_t^a = \bar{K}_0^a + X_1 e^{\gamma_1 t} + X_2 e^{\gamma_2 t}. \quad (3.45)$$

for $t \geq T$,

$$q_t^a = \bar{q}_t^a + \frac{a_2 v_2}{\gamma_1 - a_1 - a_2 v_1} X_1' e^{\gamma_1 t}, \quad (3.46)$$

$$K_t^a = \bar{K}_t^a + X_1' e^{\gamma_1 t}. \quad (3.47)$$

Equations (3.46) and (3.47) indicate that, after policy implementation at time T , the world equity market and capital stock will adjust continuously from some new initials, which produce arbitrary constant X_1' , to their new steady-state values. X_1' can be determined from (3.44)-(3.47). Subtracting (3.46) and (3.47) from (3.44) and (3.45) respectively gives

$$\frac{a_2 v_2}{\gamma_1 - a_1 - a_2 v_1} (X_1 - X_1') e^{\gamma_1 T} + \frac{a_2 v_2}{\gamma_2 - a_1 - a_2 v_1} X_2 e^{\gamma_2 T} = (\bar{q}_t^a - \bar{q}_0^a), \quad (3.48)$$

$$(X_1 - X_1') e^{\gamma_1 T} + X_2 e^{\gamma_2 T} = (\bar{K}_t^a - \bar{K}_0^a). \quad (3.49)$$

Once the innovations that produce $\Delta \bar{q} = \bar{q}_t^a - \bar{q}_0^a$ and $\Delta \bar{K} = \bar{K}_t^a - \bar{K}_0^a$ are known, $(X_1 - X_1')$ can be solved from (3.49) and is then substituted into (3.48) to derive expressions for $(X_1 - X_1')$ and X_2 at T .

8.2.2. Difference System

The world difference system is expressed as a three-dimensional differential-equation system $\dot{q}^d$ is obtained by subtracting equation (3.25b) from (3.25a), $\dot{K}^d$ is obtained by subtracting (3.26b) from (3.26a) and $\dot{E}$ is given as (3.30). The three dynamics are all functions of differences between the corresponding underlying variables of the two economies and can be expressed in the matrix form as

$$I\mu^d = Cv^d + D\kappa^d, \quad (3.50)$$

$$\mu^d = \begin{bmatrix} q^d \\ K^d \\ \dot{E} \end{bmatrix}, \quad v^d = \begin{bmatrix} q^d - \bar{q}^d \\ K^d - \bar{K}^d \\ E - \bar{E} \end{bmatrix}, \quad \kappa^d = \begin{bmatrix} G_N^d - \bar{G}_N^d \\ \tau^d - \bar{\tau}^d \end{bmatrix},$$

$$I = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}, \quad D = \begin{bmatrix} a_2 v_4 & a_3 \\ b_1 v_4 & 0 \\ \frac{\theta \eta v_4}{1+2\eta v_3} & 0 \end{bmatrix},$$

$$C = \begin{bmatrix} a_1 + a_2 v_1 & a_2 v_2 & 2a_2 v_3 - a_4 \theta \\ b_1 v_1 & b_2 + b_1 v_2 & 2b_1 v_3 \\ \frac{\theta \eta v_1}{1+2\eta v_3} & \frac{\theta \eta v_2}{1+2\eta v_3} & 0 \end{bmatrix},$$

where $(2a_2 v_3 - a_4 \theta) = (\alpha_3 - \alpha_4) < 0$, $(b_2 + b_1 v_2) = \beta_2 < 0$ and $b_1 v_4 = \beta_4 < 0$ (see (3.27) and (3.28) for explanations).

The characteristic equation of the world difference system is given by

$$[\rho I - C] = \begin{bmatrix} \rho - a_1 - a_2 v_1 & -a_2 v_2 & -(2a_2 v_3 - a_4 \theta) \\ -b_1 v_1 & \rho - b_2 - b_1 v_2 & -2b_1 v_3 \\ -\frac{\theta \eta v_1}{1 + 2\eta v_3} & -\frac{\theta \eta v_2}{1 + 2\eta v_3} & \rho \end{bmatrix} \quad (3.51)$$

$$= \rho^3 - \Lambda_1 \rho^2 + \Lambda_2 \rho - \Lambda_3 = 0,$$

where ρ 's are eigenvalues of the characteristic equation

The following general relationships between eigenvalues and the elements of a 3x3 matrix may be employed to determine the stability of the difference system

$$\rho_1 + \rho_2 + \rho_3 = -\Lambda_1 = -(c_{11} + c_{22} + c_{33}) \stackrel{>}{<} 0, \quad (3.52)$$

$$\rho_1 \rho_2 + \rho_1 \rho_3 + \rho_2 \rho_3 = \Lambda_2$$

$$= c_{11}c_{22} + c_{11}c_{33} + c_{22}c_{33} - c_{13}c_{31} - c_{23}c_{32} - c_{12}c_{21} < 0, \quad (3.53)$$

$$\rho_1 \rho_2 \rho_3 = \Lambda_3 = \text{Det}[C]$$

$$= (c_{13}c_{32}c_{21}) + (c_{12}c_{23}c_{31}) - (c_{12}c_{31}c_{22}) - (c_{11}c_{32}c_{23}) < 0, \quad (3.54)$$

where the c_{ij} 's are the elements of the coefficient matrix C in (3.50), Λ_1 is the trace of the matrix, and Λ_3 is the determinant of the matrix. The sign for the trace of C , or Λ_1 in (3.52),

is inconclusive since c_{22} is negative and c_{33} is zero. In equation (3.53), $c_{11}c_{33} = c_{22}c_{33} = 0$, $c_{11}c_{22} < 0$ and $c_{13}c_{31} < 0$, Δ_2 is therefore unambiguously negative. The determinant of C is unambiguously negative since the products in the first and the second brackets are negative. Therefore the saddlepoint stability for the three-dimensional difference system is satisfied.

The negative determinant of C implies that the system has either one or three negative roots. Given that (3.53) is negative, there can be only one negative root. The world difference subsystem is therefore saddlepoint stable with one negative root. If we further assume that the three roots are such that $\rho_1 < 0 < \rho_2 < \rho_3$, ρ_1 is then the stable root that works to keep the adjustment of the system along the saddlepoint path toward equilibrium.

The dynamics of the three-dimensional world difference system may be analyzed by examining two-dimensional cross-sections indicated by the second order principal submatrices.³⁸ Since there is only one negative root in the differential equation system, after a disturbance, the equity price, the capital stock and the real exchange rate will all adjust along a unique converging saddle path. The intrinsic stability of the adjustment paths for the two cross-sections can be solved from submatrices of coefficient matrix C in equation (3.50).

The first two-dimensional submatrix is in $[q^d, K^d]$ space and is given by:

$$I\mu_1^d = C_1 v_1^d, \quad (3.55)$$

$$\mu_1^d = \begin{bmatrix} q^d \\ K^d \end{bmatrix}, \quad v_1^d = \begin{bmatrix} q^d - \bar{q}^d \\ K^d - \bar{K}^d \end{bmatrix},$$

³⁸A similar method is used in Ambler (1988, 1989).

$$C_1 = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} = \begin{bmatrix} a_1 + a_2 v_1 & a_2 v_2 \\ b_1 v_1 & b_2 + b_1 v_2 \end{bmatrix} < 0,$$

where subscript 1 denotes the first submatrix and $b_2 + b_1 v_2 < 0$

The characteristic equation of the first submatrix is given by

$$[\rho I - C_1] = \begin{bmatrix} \rho - a_1 - a_2 v_1 & -a_2 v_2 \\ -b_1 v_1 & \rho - b_2 - b_1 v_2 \end{bmatrix} = 0.$$

The second two-dimensional submatrix is in $[E, K^d]$ space and is given by

$$I\mu_2^d = C_2 v_2^d, \quad (3.56)$$

$$\mu^d = \begin{bmatrix} K^d \\ E \end{bmatrix}, \quad v^d = \begin{bmatrix} K^d - \bar{K}^d \\ E - \bar{E} \end{bmatrix},$$

$$C_2 = \begin{bmatrix} c_{22} & c_{23} \\ c_{32} & c_{33} \end{bmatrix} = \begin{bmatrix} b_2 + b_1 v_2 & 2b_1 v_3 \\ \frac{\theta \eta v_2}{1 + 2\eta v_3} & 0 \end{bmatrix} < 0.$$

where subscript 2 denotes the second submatrix.

The characteristic equation for the second submatrix is given by

$$[\rho I - C_2] = \begin{bmatrix} \rho - b_2 - b_1 v_2 & -2b_1 v_3 \\ -\frac{\theta \eta v_2}{1 + 2\eta v_3} & \rho \end{bmatrix} = 0.$$

Saddlepoint stability requires that the determinant of both C_1 and C_2 be negative, which is unambiguously satisfied

Figure 3.2(a) illustrates the relationship between the world equity price differential and the world capital stock differential. The slopes of schedules $\dot{q}^d = 0$, $\dot{K}^d = 0$ and the saddlepoint path are similarly derived as those obtained for the average subsystem and depicted in Figure 3.1. The equity price differential and the capital stock differential move in opposite directions along the stable adjustment path towards the equilibrium.

Figure 3.2(b) describes the relationship between the real exchange rate and the world capital stock differential. The slopes of schedules $\dot{K}^d = 0$, $\dot{E} = 0$ and the saddle path of the second submatrix are derived as follows:

$$\left. \frac{(K^d - \bar{K}^d)}{(E - \bar{E})} \right|_{\dot{K}^d=0} = -\frac{2b_1v_3}{b_2+b_1v_2} > 0, \quad 2b_1v_3 > 0, \quad b_2+b_1v_2 < 0,$$

$$\left. \frac{(K^d - \bar{K}^d)}{(E - \bar{E})} \right|_{\dot{E}=0} = \infty,$$

$$\left. \frac{(K^d - \bar{K}^d)}{(E - \bar{E})} \right|_{ss} = \frac{2b_1v_3}{\rho_1 - b_2 - b_1v_2} > 0, \quad \rho_1 < 0, \quad b_2+b_1v_2 < 0.$$

Schedule $\dot{K}^d = 0$ is upward sloping because a larger capital stock raises the relative price of nontraded goods, implying a real appreciation ($E < \bar{E}$). The equilibrium then requires a depreciation. Schedule $\dot{E} = 0$ is vertical because, at any level of the capital stock, the real

Figure 3.2(a). Equilibrium of q^d / K^d Cross Section

Figure 3.2(b). Equilibrium of E / K^d Cross Section

exchange rate may fluctuate in response to other shocks. The slope of the saddle path is ambiguous since ρ_1 and $\beta_2 = b_2 + b_1 v_2$ are both negative, and $(\rho_1 - \beta_2)$ may be greater or smaller than zero. However, saddlepoint stability requires that it slope downward, which implies that an increase in the capital stock is accompanied by an appreciation of the real exchange rate. This requirement is met if $|\rho_1| > |\beta_2|$.

9. Concluding Remarks

This chapter develops a two-country macroeconomic model in which the investment decision is made by optimizing capital-producing firms according to Tobin's Q . The equity price is determined by the marginal value of capital, and the real exchange rate is based on the relative fundamentals of the two economies. Innovations in real economic variables, such as changes in government spending, tax rates and the real interest rate, affect expected returns on capital, which in turn induce dynamic adjustments of the equity price, the capital stock and the real exchange rate of each economy.

The dynamics of the two economies are then decoupled into the world average and relative fundamentals to reflect how macroeconomic innovations may affect both economies. Particularly, this distinction provides a useful framework in which the long-run cointegrating relationship between equity markets and the short-run deviations of the equity price differential from the equilibrium will be investigated theoretically, which is an objective of the next chapter.

CHAPTER IV

EFFECTS OF FUNDAMENTAL INNOVATIONS ON WORLD EQUITY MARKETS

1. Introduction

Based on the theoretical framework discussed in the last chapter, this chapter examines how equity prices, capital accumulation and the real exchange rate of the two economies respond to macroeconomic news that affect fundamental determinants of equity markets

The different effects on the dynamics of the model produced by changes in government expenditures, tax rates and real interest rates in either or both economies demonstrate the following: (1) While a temporary innovation in fundamentals diverts the equity price, the exchange rate and investment away from their long-run equilibrium paths, a permanent disturbance changes the paths. (2) While a policy announcement induces adjustments in equity prices and the real exchange rate before the policy is implemented, an unanticipated policy usually triggers an overreaction in these two variables. (3) While a symmetric policy innovation in the two economies produces comovements in their equity markets, an asymmetric policy innovation may affect their equity markets differently, at least in the short run, because it may change the relative fundamentals. Over the long run, repercussion effects of the innovation and portfolio adjustment will eliminate the deviations of the equity price differential from its equilibrium level. The result therefore suggests that the integration of world equity markets holds from a long-run perspective.

Sections 2, 3, and 4 of this chapter will discuss respectively the effects of innovations in government expenditure, the tax rate and the real interest rate in different scenarios. Conclusions drawn from the analytical results are summarized in Section 5.

2. Effects of Fiscal Expansions on World Equity Markets

Impacts of expansionary government spending on the world investment and equity markets depend on, among many factors, which goods-producing sector is most directly affected. If both governments spend more on traded goods by similar amounts, the relative price of nontraded goods in terms of traded goods, P and P^* , fall proportionally and the relative price between the two economies, $E = [(P_N^*/P_T^*)/(P_N/P_T)]$, remains unchanged. Similarly, if only one government increases its purchases of traded goods by an amount large enough to raise the world price for traded goods, the relative price between the two economies remains unchanged due to an equiproportional decrease in the national relative prices of nontraded goods.

In both scenarios, this type of expansionary fiscal policy reduces the relative cost of capital installation and raises expectations on corporate profit, which, according to equations (3.5), (3.25a), (3.25b), (3.26a) and (3.26b), will raise equity prices and capital investments in both economies in a similar way. The effects of this policy innovation will therefore not be investigated further.

In contrast, an increase in government expenditure that falls entirely on the nontraded goods sector alters the local relative price of nontraded goods in terms of traded goods. It also changes the relative price between economies if the expansion is asymmetric, meaning that only one government adopts the expansionary fiscal policy. The innovation therefore affects not only domestic but also foreign expected returns on capital.

The next section examines how a variety of situations, in which fiscal policy changes occurred in different ways, may affect world equity markets differently.

2.1. Symmetric fiscal expansions

The analysis begins with a benchmark case of symmetric unit fiscal expansions that fall on nontraded goods only. In this situation, the world averages are affected but the differences remain unchanged, that is

$$\Delta G_N = \Delta G_N^* = 1, \quad \Delta x^d \neq 0, \quad \Delta x^f = 0,$$

$$\text{where } \Delta x^d = [\Delta q^d, \Delta K^d]', \quad \Delta x^f = [\Delta q^f, \Delta K^f]'$$

The two economies may therefore be treated as one.

2.1.1. Unanticipated permanent symmetric fiscal expansions

Assuming that the world economy is initially in the steady state with $q_0^* = \bar{q}_0^*$ and $K_0^* = \bar{K}_0^*$, then unanticipated permanent fiscal expansions take place in both economies at $t = 0$. The world average system diverges from its initial equilibrium but will converge monotonically, at the rate γ_1 , to a new equilibrium, as demonstrated in the previous chapter.

The new steady-state average equity price and capital stock corresponding to the disturbed world economy will be, repeating (3.43):

$$\bar{q}_1^* = \bar{q}_0^* + \Delta \bar{q}^*, \quad (4.1)$$

$$\bar{K}_1^* = \bar{K}_0^* + \Delta \bar{K}^*. \quad (4.2)$$

Explicit expressions for effects produced by the unanticipated symmetric increases in

government expenditures on the average system are as follows

$$\text{For } t \geq 0, \quad \Delta G_N = \Delta G_N^* = 1,$$

$$q_t^* = \bar{q}_t^* + \frac{a_2 v_2}{\gamma_1 - a_1 - a_2 v_1} X_1 e^{\gamma_1 t}, \quad (4.3)$$

$$K_t^* = \bar{K}_t^* + X_1 e^{\gamma_1 t}, \quad (4.4)$$

$$\text{where } \bar{q}_t^* = \bar{q}_0^* + \frac{a_2 b_2 v_4}{A} \Delta G_N^* < 0, \quad (4.5)$$

$$\bar{K}_t^* = \bar{K}_0^* + \frac{a_1 b_1 v_4 + 2a_2 b_1 v_1 v_4}{A} \Delta G_N^* < 0, \quad (4.6)$$

$$X_1 = \frac{b_2 v_4 (\gamma_1 - a_1 - a_2 v_1)}{A v_2} = \frac{a_1 b_1 v_4 + 2a_2 b_1 v_1 v_4}{A} > 0, \quad (4.7)$$

$$A = -[(a_1 + a_2 v_1)(b_2 + b_1 v_2) + (a_2 v_2 b_1 v_1)] < 0.$$

Denominator A is the coefficient matrix in equation (3.33). X_1 is the vector of arbitrary constants obtained from the initial conditions of q^* and K^* given in equations (3.39) and (3.40) with $\Delta G_N^* = 1$. The first term on the right-hand side of equation (4.3) or (4.4) represents the intertemporal equilibrium level of the world equity price or the world capital stock that is negative due to the fiscal expansion. The second term of (4.3), which is negative, implies the deviation of the world equity price from its long-run equilibrium due to the fiscal expansion.

With γ_1 being negative, the deviation (the second term) vanishes as t becomes infinite. However, the second term of (4.4) implies that the deviation of the world capital stock from its long-run equilibrium increases as t becomes infinite.

The joint adjustment of the world average equity price and average capital stock to the fiscal expansions is illustrated in Figure 4.1. As both governments increase their purchases of nontraded goods permanently, the equilibrium for the nontraded goods market in each economy is disturbed. Its immediate consequence is that P_N and P_N^* rise instantaneously to eliminate the excess demand for nontraded goods. This results in a higher cost of capital installation and a lower expected return, $q/(1-P)$, which negatively affects the world capital-supplying industry.

Since the capital stock is slow to adjust, the world capital stock cannot fall instantly to eliminate the excess world supply of equity claims. The equity price therefore has to drop sufficiently to clear the world equity market. In Figure 4.1(a), schedule $\dot{q} = 0$ shifts down to the left and the price of equity jumps down instantly to point B to bring the adjustment onto the new saddlepoint path $s's'$.

At point B, q^* is below its long-run equilibrium level $\bar{q}^*$. The undershooting in world equity markets immediately restores equity market equilibrium. Meanwhile, it allows for future increases in the equity price as the capital stock gradually falls over the entire adjustment period. At point B, the rate of capital formation, J/K , starts to decline due to a lower $(q-1)/P$ ratio (see equation (3.13)).

During this period of adjustment, the world capital stock declines gradually along the new saddle path $s's'$, which is accompanied by a continuous increase in the equity price until

Figure 4.1(a). World Response to an Unanticipated Permanent Fiscal Expansion

Figure 4.1(b). Time Paths of q^a and K^a

the world equity market reaches a new long-run equilibrium where schedules $\dot{q}' = 0$ and $\dot{K}' = 0$ intersect each other. The increase in the equity price is caused by two factors. First, the decline in capital installation increases the marginal value of the new capital. Second, the decline in capital installation also reduces the excess demand for nontraded goods and therefore the relative price of nontraded goods falls. On both accounts, the initial negative effect of the higher relative price on the profitability of the capital industry is alleviated.

At the new equilibrium C, the higher government spending completely crowds out investment. The increase in the demand for nontraded goods induced by the fiscal expansion is exactly offset by the decrease in the demand for nontraded goods from the capital-supplying sector due to capital decumulation. The relative price of nontraded goods returns to its initial level. World equity markets completely recover from the initial negative impact of the expansionary fiscal policies.³⁹

What happens to the exchange rate? In a small open economy model, such as the one by Murphy (1989), an expansionary fiscal policy that affects the domestic nontraded sector and the domestic relative price will alter the real exchange rate since the price of the rest of the world is held constant. The same fiscal policy, when adopted by both governments, does not have an impact on the exchange rate in this two-country model. The economic intuition is straightforward. Symmetric increases in G_N and G_N^* will raise P and P^* proportionally,

³⁹This result is based on equations (3.18a) and (3.18b), which suggest that the government expenditure is financed by both increased taxation and public borrowing. However, if the fiscal expansion is financed by an increase in the rate of tax only, the negative effect of the policy on the capital market will be stronger because it requires a greater increase in the tax rate, which reduces net income to a greater extent, thereby inducing a larger decrease in investment and a slower recovery of the equity market.

which leaves E unaffected.⁴⁰

Figure 4.1(b) shows the time paths of q^* and K^* . During the entire adjustment period, while the world capital stock undergoes a continuous decumulation, the equity price initially undershoots its long-run equilibrium and then increases continuously as the capital stock becomes scarce and the marginal value of the capital goes up

2.1.2. Unanticipated transitory symmetric fiscal expansions

If the unit increases in both governments' expenditures on nontraded goods occur at time $t = 0$ only and return to their original levels thereafter, the long-run adjustments of the world equity price and capital accumulation in response to this temporary policy innovation differ from those produced by a permanent expansion.

As depicted in Figure 4.2(a), the immediate effects of a temporary fiscal expansion that brings the world equity market to point B are similar to those of a permanent increase a higher cost of installation, a lower expected return on capital, $(q-1)/P$, and an undershooting of the equity market. From the time the change occurs to the time world government expenditure returns to its initial level, the average world capital stock falls continuously accompanied by a gradual rise in the equity price from point B.

After government expenditure returns to its initial level at time $t = T > 0$, domestic and foreign relative prices of nontraded goods in terms of traded goods drop at once to reduce the excess supplies of nontraded goods. Encouraged by the lower cost, capital

⁴⁰Symmetric shocks with identical magnitudes rarely happen in the real world. The case is discussed to help readers understand the mechanisms that produce the dynamics of the model.

Figure 4.2 (a). World Response to an Unanticipated Temporary Fiscal Expansion

Figure 4.2 (b). Time Paths of q^a and K^a

installation starts to rise at some point, say point C, and the marginal value of capital falls. From point C to point A, as the capital stock K^* accumulates, q^* declines and $\dot{K}^* = 0$ gradually shifts back along the stable path ss to its initial equilibrium point A.

2.1.3. Anticipated symmetric fiscal expansions

The dynamic adjustments of the world capital stocks and equity prices in response to the announcement of the fiscal expansions effective at $t = T$ are given as follows

$$\text{For } 0 \leq t < T, \quad \Delta G_N^* = 0,$$

$$q_t^* = \bar{q}_0^* + \frac{a_2 v_2}{\gamma_1 - a_1 - a_2 v_1} X_1 e^{\gamma_1 t} + \frac{a_2 v_2}{\gamma_2 - a_1 - a_2 v_1} X_2 e^{\gamma_2 t}, \quad (4.8)$$

$$K_t^* = \bar{K}_0^* + X_1 e^{\gamma_1 t} + X_2 e^{\gamma_2 t}; \quad (4.9)$$

$$\text{for } t \geq T, \quad \Delta G_N^* = 1,$$

$$q_t^* = \bar{q}_t^* + \frac{a_2 v_2}{\gamma_1 - a_1 - a_2 v_1} X_1' e^{\gamma_1 t}, \quad (4.10)$$

$$K_t^* = \bar{K}_t^* + X_1' e^{\gamma_1 t}, \quad (4.11)$$

where $\bar{q}_t^*$ and $\bar{K}_t^*$ in (4.10) and (4.11) are as given in (4.5) and (4.6), and X_1 's are the new arbitrary constants produced by the new initial conditions at the time of policy implementation. Subtracting (4.10) and (4.11) from (4.8) and (4.9) respectively gives

$$\frac{a_2 v_2}{\gamma_1 - a_1 - a_2 v_1} (X_1 - X'_1) e^{\gamma_1 T} = \Delta \bar{q}^a - \frac{a_2 v_2}{\gamma_2 - a_1 - a_2 v_1} X_2 e^{\gamma_2 T}, \quad (4.12)$$

$$\text{where } (X_1 - X'_1) e^{\gamma_1 T} = \Delta \bar{K}^a - X_2 e^{\gamma_2 T}. \quad (4.13)$$

$X_1 - X'_1$ and X_2 can be determined from (4.12) and (4.13) (at $t = T$) by first substituting (4.13) into (4.12) to solve for X_2 , and then using the result to solve for $X_1 - X'_1$. The economic explanations to (4.10) and (4.11) are the same as those to (4.3) and (4.4).

The announcement effects of the policy change are illustrated in Figure 4.3. At the announcement day $t = 0$, people anticipate a step increase in the cost of capital and a decrease in future net income after the policy implementation. The forward-looking equity market therefore undergoes a jump decrease to point B, which reflects a revision in expectations of future profits. Aware of the current fall in the equity market and expecting a future rise in the installation cost, firms in the capital industry start to reduce their investment.

During the period prior to the policy implementation, the world economy moves from point B to point B' with the continuously declining equity prices and capital stocks. The implementation of the fiscal policy at $t = T$ leads to further decumulation of the capital stock. At the new equilibrium point C, q^* returns to its initial level and the capital stock, K^* , is reduced.

The distributional effects of the policy on each economy are symmetric and can be obtained by multiplying the results of (4.3) and (4.4), or (4.10) and (4.11) by one half.

Figure 4.3 (a). World Response to an Anticipated Permanent Fiscal Expansion

Figure 4.3 (b). Time Paths of q^a and K^a

In the above situations, both economies adopt similar expansionary fiscal policies. Therefore, world equity markets fall simultaneously with identical magnitudes and in the same direction. Although the above analyses do not have much to tell about the correlation of world equity markets, it explains the mechanisms of equity market movements and is useful for the following analyses of various situations in which innovations are asymmetric and may affect equity prices of different economies differently.

2.2. An asymmetric fiscal expansion

It is more interesting to examine the effects of an asymmetric policy change. Unanticipated or anticipated, an asymmetric innovation will affect the world relative economic fundamentals, producing dynamic adjustments from both the average and the difference subsystems. The net impact of the policy innovation on each economy can be obtained respectively as.

$$\Delta x = \frac{2\Delta x^a + \Delta x^d}{2}, \quad \Delta x^* = \frac{2\Delta x^a - \Delta x^d}{2}. \quad (4.14)$$

Once the effect on each subsystem is determined, the combination of the results gives the distributional policy effects on the endogenous variables of each economy.

An important implication of (4.14) is that, although the effects of an asymmetric policy innovation on the local economy are unambiguous, its effects on the other economy are *a priori* ambiguous. For instance, if a policy innovation occurs in the domestic economy, it increases both x^a and x^d . The first equation in (4.14), therefore, will be unambiguously

positive and the second equation will be inconclusive. Conversely, if a policy innovation occurs in the foreign economy, it increases x^a but reduces x^d . The first equation will be inconclusive and the second equation will be unambiguously positive. The net change can only be determined with information about the exact magnitudes of the effects on the average and difference systems. However, it is difficult to determine the exact magnitudes of the effects on the difference subsystem because it involves solving the initial values of all endogenous variables from a three-dimensional differential-equation system.

One solution to this problem is to use the method of Laplace transforms that converts a differential-equation system into an arithmetical-equation system. In this way, the difficulty of finding initial conditions and determining appropriate values for arbitrary constants in the general solution does not arise. Once the initial values and the arbitrary constants are determined, the impacts on the difference system produced by shocks can be formulated. Recent applications of the technique in perfect foresight macroeconomic models include Obstfeld and Rogoff (1984), Aoki (1986) and Ambler (1988, 1989). An application of the technique in the context of a fiscal policy is discussed in Appendix B.

2.2.1 Effects of an unanticipated domestic fiscal expansion

Let's consider a permanent unanticipated domestic fiscal expansion that changes both average and difference subsystems:

$$\Delta G_N = 1, \quad \Delta G_N^* = 0, \quad \Delta x^a \neq 0, \quad \Delta x^d \neq 0$$

Its effects on the world average equity price and capital stock are similar to those produced by symmetric unanticipated fiscal expansions:

$$\text{for } t \geq 0, \quad \Delta G_N = 1, \quad \Delta G_N^* = 0.$$

$$q_t^s = \bar{q}_t^s + \frac{a_2 v_2}{\gamma_1 - a_1 - a_2 v_1} X_1 e^{\gamma_1 t}, \quad (4.15)$$

$$K_t^s = \bar{K}_t^s + X_1 e^{\gamma_1 t}, \quad (4.16)$$

$$\text{where } \bar{q}_t^s = \bar{q}_0^s + \frac{a_2 b_2 v_4}{2A} \Delta G_N < 0, \quad (4.17)$$

$$\bar{K}_t^s = \bar{K}_0^s + \frac{a_1 b_1 v_4 + 2a_2 b_1 v_1 v_4}{2A} \Delta G_N < 0, \quad (4.18)$$

$$X_1 = \frac{b_2 v_4 (\gamma_1 - a_1 - a_2 v_1)}{2A v_2} = \frac{a_1 b_1 v_4 + 2a_2 b_1 v_1 v_4}{2A} > 0. \quad (4.19)$$

Since the unit shock comes from one economy instead of both economies, the magnitudes of the effects formulated in (4.15)–(4.19) are only half as much in value as those produced by an symmetric fiscal expansion (see equations (4.3)–(4.7)). However, the dynamic adjustments of the world average equity price and capital stock are similar to those described in Section 2.1.1 and illustrated in Figures 4.1.

What really distinguishes the effects of an asymmetric fiscal expansion from those of a symmetric one is that the former alters the relative fundamentals, the relative price, in

particular, between the two economies. The change in the relative fundamentals may have different impacts on expected equity returns in the two economies, at least in the short run

The immediate effect of an unanticipated increase in the domestic government spending on nontraded goods, as illustrated in Figure 4.4(a), is a jump increase in the domestic relative price of nontraded goods to clear the market. This produces two short-run effects on the world differential system.

The first effect is reflected in a rise in the domestic cost of capital installation, which in turn reduces the expected net income to capital. Forward looking equity markets react to the lower expected income by reducing their demand for domestic equities. Since the capital stock cannot be depleted instantly to eliminate the excess supply of equity claims, it requires an instantaneous decrease in the domestic equity price to clear the domestic equity market. This effect is indicated by a downward shift of schedule $\dot{q}^d = 0$ because of an undershooting of the equity price differential to point B in Figure 4.4(a). Given that returns on equities of different economies are initially equal, the undershooting or the decrease in the world equity price differential implies that the return on the domestic equity falls short of the returns on the foreign equity.⁴¹

The second effect is reflected in an instantaneous appreciation, or an undershooting, of the real exchange rate to point B in Figure 4.4(b) due to the higher domestic relative price

⁴¹The world equity price differential involves two related concepts. If two equity markets are perfectly correlated, equity returns on the two markets are continuously equalized. The continuous equalization of equity returns will be reflected in perfect comovements of the equity prices of the two markets, which implies that their equity price differential never changes. This perfect linear relationship corresponds exactly to the time series concept of perfect cointegration. However, due to various disturbances, foreseen or unforeseen, the equity price differential may deviate from its long-run level from time to time. Consequently, the two markets are only cointegrated in the long run.

Figure 4.4(a). q^d/K^d Cross Section: Response to an Anticipated or an Unanticipated Domestic Fiscal Expansion

Figure 4.4(b). E / K^d Cross Section: Response to an Anticipated or an Unanticipated Domestic Fiscal Expansion

of nontraded goods. Since traded goods produced in different economies are perfect substitutes, the demand for traded goods will shift to the foreign products as the domestically-produced traded goods become relatively more expensive. Recall that the traded goods sector is capital intensive. The lower demand for the domestically-produced traded goods necessarily reduces the demand for domestic capital, which implies a lower rental income for the home capital-supplying industry.

The two effects together lead to a lower $(q-1)/P$ and a decline in domestic investment. The undershooting of the real exchange rate and the undershooting of the domestic equity price after the policy innovation place the world equity price differential and capital stock differential on the new stable adjustment paths $s's'$ in both Figure 4 4(a) and 4 4(b).

During the intertemporal adjustment, the $\dot{K}^d = 0$ schedule continuously shifts leftward along saddlepoint path $s's'$, reflecting a falling capital stock differential. As explained earlier, the falling domestic capital stock gradually increases the marginal value of domestic capital and alleviates the initial upward pressure on the domestic relative price of nontraded goods produced by the fiscal expansion. These will eventually reverse the downward movements of the equity price differential and the exchange rate at point B from which both variables will begin to rise monotonically along their respective adjustment paths to a new equilibrium.

The initial effect of the domestic fiscal expansion on the foreign economy is an increase in the demand for the foreign-produced traded goods due to the real depreciation. To meet this increased demand, the foreign traded sector needs to raise production, which requires more foreign capital. This in turn raises rental revenues, which translates into a higher expected income in the foreign capital industry.

While the return on domestic capital is lower due to the domestic fiscal expansion, the prospect of a higher return in the foreign capital industry may induce a portfolio adjustment from domestic to foreign equities. Therefore, the foreign equity price will rise as the domestic equity price falls, which will result in a smaller equity price differential, or a deeper undershooting, than if there has not been the portfolio adjustment from the domestic to the foreign equities. It follows that there may be a negative correlation between equity prices across markets after an asymmetric fiscal expansion, a result inconsistent with the conventional belief.

However, this negative correlation and the resulted deviation from the equilibrium may not persist over the long run. A falling capital stock at home due to the unfavorable change in the domestic equity market gradually increases the marginal return to capital, therefore the market value of capital at home. The converse occurs at abroad. In addition, the exchange rate will eventually return to its long-run level as the domestic investment is gradually crowded out and the excess demand for the domestically-produced nontraded goods is eliminated. The cost of investment will then return to its initial level. Finally, a lower domestic capital stock during the entire adjustment process means a decreasing demand by the domestic capital industry for foreign traded goods as an input in the production of capital. This will dampen the initial positive effect of the policy innovation on the expected returns of the foreign capital industry. These changes in real economic activity, accompanied by continuous portfolio adjustments, will eventually equalize the returns on equities in the two markets.

A word of caution is in order at this point. Under the assumption of perfect foresight,

the foreign stock market is able to predict that the change in the equity return differential produced by the domestic fiscal expansion will not last in the long run. Therefore, the portfolio adjustments may be deterred even when short-run profit opportunities exist if investors change their portfolios by increasing their equity holdings on the positively-affected foreign capital. If this is the case, the negative correlation may not occur.

2.2.2. Effects of an anticipated domestic fiscal expansion

The effects of a preannounced permanent domestic fiscal expansion on the world average system are similarly derived as (4.8)-(4.13) but with $\bar{q}^*$ and $\bar{K}^*$ given as in (4.17) and (4.18) respectively.

The adjustment process of the difference system in response to a preannounced domestic fiscal expansion is illustrated in Figures 4.4(a) and 4.4(b), as a comparison to that induced by an unanticipated domestic fiscal expansion. At the announcement of the domestic fiscal expansion, the exchange rate and the equity price differential drop to point B'. During the period prior to policy implementation, while they continue to decrease, the domestic capital stock, at the expectation of a higher cost of investment, starts to fall too. At the time that the policy change takes effect, the adjustments of q^d , K^d and E from points B'' and thereafter are similar to those in response to an unanticipated fiscal expansion.

The exact distributional effects of the domestic fiscal policy on different economies can be obtained, in the way defined in (4.14), by combining respectively the effects of the innovation on the average system formulated in (4.15) and (4.16) with those on the difference system derived in Appendix B.

The analytical results in this section demonstrate that a domestic fiscal expansion, unanticipated or anticipated, changes the world relative economic fundamentals, which in turn reduces the world equity price differential in the short run, the world capital differential in the short run and long run, and leads to a jump appreciation of the domestic currency.

It is of interest to notice that the adjustment of the world equity price differential in response to a domestic fiscal expansion is consistent with some observed equity market regularities. The dynamic adjustment of the model suggests that, in the short run, equity returns of different economies may move apart from each other due to the opposite effects an asymmetric policy disturbance may produce on the two economies. The result provides one explanation about why world equity returns are often found to be unequal.

However, over time, the deviation of the equity price differential from its equilibrium is gradually eliminated by international portfolio adjustment and the economic repercussion effects associated with the innovation. Therefore, the model suggests that a linear relationship between equity prices of different economies exists only in the long run.

3. Effects of a Domestic Corporate Tax Reduction on World Equity Markets

In this section, the effects of an anticipated unit reduction in the domestic corporate tax rate are examined. The policy change implies:

$$\Delta \tau = -1, \quad \Delta \tau^* = 0, \quad \Delta x^d \neq 0, \quad \Delta x^f \neq 0.$$

Effects of this innovation on the average system are formally derived from (3.33) as follows

for $0 \leq t < T$, $\Delta\tau = 0$, $\Delta\tau^* = 0$,

$$q_t^a = \bar{q}_0^a + \frac{a_2 v_2}{\gamma_1 - a_1 - a_2 v_1} X_1 e^{\gamma_1 t}, \quad (4.20)$$

$$K_t^a = \bar{K}_0^a + X_1 e^{\gamma_1 t}, \quad (4.21)$$

for $t \geq T$, $\Delta\tau = -1$, $\Delta\tau^* = 0$,

$$q_t^a = \bar{q}_t^a + \frac{a_2 v_2}{\gamma_1 - a_1 - a_2 v_1} X_1' e^{\gamma_1 t}, \quad (4.22)$$

$$K_t^a = \bar{K}_t^a + X_1' e^{\gamma_1 t}, \quad (4.23)$$

$$\text{where } \bar{q}_t^a = \bar{q}_0^a - \frac{a_3(b_2 + b_1 v_2)}{2A} \Delta\tau > 0, \quad (4.24)$$

$$\bar{K}_t^a = \bar{K}_0^a - \frac{a_3 b_1 v_1}{2A} \Delta\tau > 0, \quad (4.25)$$

$$X_1 = \frac{a_3(b_2 + b_1 v_2)(\gamma_1 - a_1 - a_2 v_1)}{2A a_2 v_2} = \frac{a_3 b_1 v_1}{2A} < 0. \quad (4.26)$$

Equations (4.24) and (4.25) indicate that a unit reduction in the tax rate increases intertemporal levels of the world average equity price and capital stock. Equation (4.22) shows that the world average equity price will converge monotonically from above to its long-run equilibrium after the initial jump to X_1' and equation (4.23) indicates that the world

average capital stock will increase ever after

These adjustments are illustrated in Figure 4.5. The announcement of a domestic tax reduction that is to take place at some time in the future, say at time T , leads to an immediate jump increase of q^* to point B' . This reaction of the equity price at the announcement can be explained by the forward-looking nature of the equity market. Changes in the equity price are associated not only with current events that affect returns on capital but also reflect the revision of investors' expectations of future earnings and dividends. The anticipated domestic permanent corporate tax reduction at time T raises expected future returns on capital, which in turn increases the current demand for equity claims. Since the capital stock cannot change in the short run, the excess demand on the equity market requires an immediate increase in the equity price. Consequently, schedule $\dot{q}^* = 0$ shifts up and to the right as q^* undergoes instantaneous overshooting above its long-run equilibrium. The overshooting restores the equity market equilibrium and, in addition, makes room for a future decline of the equity price as the world average capital stock gradually increases.

During the period prior to the tax reduction, the equity market continuously moves up. Meanwhile, with a higher market value of capital, therefore a higher $(q-1)/P$ ratio at a given installation cost of capital, and an expected lower tax rate, the domestic capital-supplying sector increases the rate of capital installation. The world average capital stock therefore moves from B' to B'' in Figure 4.5(a).

At the time of the policy implementation, the marginal return to capital installation starts to fall as the world accumulates capital. This results in a falling equity price, which takes place along the new stable adjustment path $s's'$. At the new equilibrium point C , both the

Figure 4.5 (a). World Response to an Anticipated or an Unanticipated Domestic Tax Cut

Figure 4.5 (b). Time Paths of q^a and K^a in Response to an Anticipated Domestic Tax Cut

world equity price and the capital stock are higher than their initial levels.

In the case of an unanticipated reduction in the tax rate, the world average equity price jumps immediately and sufficiently to bring the average system to point B on the new saddle path. The adjustment thereafter is the same as the adjustment produced by the anticipated tax reduction.

Exact mathematical expressions for the effects of the domestic unit reduction in the corporate tax rate on the world difference system can be similarly obtained as demonstrated in Appendix B. Adjustments of the world difference system in response to both anticipated and unanticipated domestic tax reductions are illustrated in Figure 4.6.

The short-run effect of an anticipated domestic tax reduction is an overshooting of the domestic equity price. As a result, the world equity price differential jumps to point B' in Figure 4.6(a), which reflects investors' expectations of a higher net income for the domestic capital-supplying industry due to the tax reduction.

Unlike the short-run effect of a domestic fiscal expansion, the domestic corporate tax reduction announcement does not produce a jump reaction in the real exchange rate. Instead, it causes a gradual real appreciation. This occurs because, although the expected tax reduction increases profit expectations, which in turn stimulates capital installation, the capital installation adjusts only gradually. The implication is that there will not be a sudden increase in the demand for domestic nontraded goods at the policy announcement and, therefore, there will be no need for an immediate jump in the domestic relative price of nontraded goods to clear the goods market. Since the real exchange rate changes negatively in proportion to the world price differential of nontraded goods according to (3.32), it follows that there will be

no jump appreciation in the real exchange rate in the period prior to the tax reduction.

Throughout the adjustment period prior to and after the tax reduction, the domestic capital stock grows. Besides, dividends to share holders, which is by assumption equal to profits of the capital-producing industry, increase at the policy implementation. This in turn raises domestic consumption of both traded and nontraded goods. The increase in investment and consumption will result in a appreciation of the real exchange rate as the gradually increasing demand for domestic nontraded goods raises the relative prices of nontraded goods at home. These adjustments are indicated by the outward shifts of both schedules $\dot{E} = 0$ and $\dot{K} = 0$ and the movements of the exchange rate and the world capital stock differential along the stable path ss in Figure 4.6(b).⁴²

Unlike an asymmetric fiscal policy, which may cause opposite movements of the two equity markets, the foreign equity market is similarly affected by the domestic corporate tax reduction. The greater domestic investment and consumption due to the domestic tax reduction increase the demand for the foreign-produced traded goods. The real appreciation also stimulates the foreign traded-goods sector. Both effects lead to an increase in the demand for foreign capital, and therefore generate higher incomes for the foreign capital-supplying firms. As a result, the foreign equity price increases as well.

However, the immediate increase in the equity price may be stronger at home than abroad. Although the tax reduction affects the domestic equity market immediately and

⁴²The adjustment path of the real exchange rate after the policy implementation depends on the way consumers spend their extra incomes from the tax reduction. If consumers spend all the extra incomes immediately, given the supply of nontraded goods, there will be a jump appreciation of the exchange rate. But if they divide their extra incomes between savings and consumption, there will no immediate and significant effect on the relative price of nontraded goods, therefore the real exchange rate

directly as people expect higher corporate profits at home, its impact on the foreign equity market may be indirect and less effective as the effect of a strong domestic economy spills over first to the foreign goods market and then to the foreign capital market. The domestic tax reduction may therefore create a jump increase in the domestic equity price, but a lagged increase in the foreign equity price. This is reflected in an overshooting of the short-run world equity price differential above its long-run level. At point B, the intertemporal domestic equity return is higher than the foreign equity return.

Moving towards a new long-run equilibrium point C, the positively correlated adjustments of the two equity markets gradually eliminate the differential between their returns created by the nonsynchronized responses of the two economies to the tax change. At point C, the equity price differential returns to its initial level. The world capital stock differential will be greater than its initial level since the domestic capital-producing industry reacts to the domestic tax reduction more than does the foreign capital-producing industry. The new real exchange rate will be below its initial level.

The analytical result of an asymmetric tax reduction suggests that there may not be a simultaneous and positive correlation between equity returns of different economies in the short run after an asymmetric innovation in economic fundamentals. In general, an equity market always responds contemporaneously to macroeconomic policy innovations at home, but may react to innovations abroad to a lesser extent and/or with a time lag if the effects of foreign innovations are not direct and immediate. Accordingly, there may not be a significant correlation between equity returns across markets in the short run. This is again consistent with the equity market regularities observed in many existing empirical studies. However,

repercussions across economies and international portfolio adjustments will eventually eliminate the equity return differential between economies. Therefore, it is expected that the positive correlation between equity returns is stronger in the long run than in the short run

4. Effects of Changes in Real Interest Rates on World Equity Markets

This section investigates effects produced by changes in real interest rates. The asset market equilibrium condition (3.5) implies that a higher interest rate is always accompanied by a lower equity price. Empirical regularities prove that the interest rate, real or nominal, is one of the most crucial factors that determine equity prices. Since there is no monetary sector in the current model, there is no on going inflation. The model therefore does not yield an adjustment process of world equity markets to changes in nominal interest rates. However, the adjustment of world equity markets to changes in real interest rates will still provide useful insight into the understanding of the relationship between interest rates and the comovement of world equity markets

As discussed in Chapter III, Section 5, the long-run equilibrium real rate of interest in each economy is predetermined by the rate of time preference that represents the representative household's marginal rate of substitution between present and future utility. Although the rate of time preference is assumed to be constant to simplify the derivation of the model, it may be endogenized in the model.

For instance, the rate of time preference may be assumed as a function of real wealth ⁴³ As wealth falls, due to either accumulated current account deficits or declining labor

⁴³See Jones and Kenen (1985), Chapter 18 and Uzawa (1968) for a discussion.

productivity, (and therefore lower labor income), households tend to consume less, which implies that they discount their expected future wealth at a higher rate

Since an investigation into the factors that change in the rate of time preference is beyond the task of the present research, the subject will not be pursued further. Instead, the attention will be focused on the effects of a change in the time preference on world equity markets.

Suppose that the rate of time preference is increased, which implies that the real interest rate will be higher. Furthermore, given the assumption of symmetry, the rates of time preference of the two economies are identical, their steady-state real interest rates are also equal. This implies that when there is an innovation in the real interest rate, only the world average system is affected.

The long-run effects of an unanticipated unit increase in real interest rates on the world averages can be expressed in formulations similar to (4.3) to (4.7) with values of $\bar{q}_t^*$, R_t^* and X_t similarly derived as:

$$\text{for } t \geq 0, \quad \Delta r = 1, \quad \Delta r^* = 1,$$

$$q_t^* = \bar{q}_t^* + \frac{a_2 v_2}{\gamma_1 - a_1 - a_2 v_1} X_1 e^{\gamma_1 t}, \quad (4.27)$$

$$K_t^* = \bar{K}_t^* + X_1 e^{\gamma_1 t}, \quad (4.28)$$

$$\text{where } \bar{q}_t^a = \bar{q}_0^a + \frac{a_4(b_2 + b_1 v_2)}{A} \Delta(r+r^*) < 0, \quad (4.29)$$

$$\bar{K}_t^a = \bar{K}_0^a + \frac{a_4 b_1 v_1}{A} \Delta(r+r^*) < 0, \quad (4.30)$$

$$X_1 = \frac{a_4(b_2 + b_1 v_2)(\gamma_1 - a_1 - a_2 v_1)}{A a_2 v_2} = \frac{a_4 b_1 v_1}{A} > 0. \quad (4.31)$$

The increases in real interest rates reduce the intertemporal levels of the world average equity price and the capital stock, as shown in (4.29) and (4.30) respectively. The world equity price will converge from below to its long-run equilibrium as suggested by (4.27); and the world capital stock will decline after the innovation as suggested by (4.28).

An illustration of the effects produced by the unanticipated increases in real interest rates on the average system is similar to that of a symmetric fiscal expansion illustrated in Figure 4.1. When there is an increase in the real interest rate, given other conditions, investors will be induced to shift their asset holdings from less attractive equities into interest-bearing bonds. Since the capital stock is slow to adjust, the excess supply of equity claims requires an immediate undershooting of world equity prices from point A to point B in Figure 4.1 to maintain the asset market equilibrium.

However, the equilibrium point B is not stable. The excess supplies of equity claims in both economies, therefore the lower world equity prices, discourage world capital investment, which gradually lowers the relative price of nontraded goods and raises the expected return on capital.

At the new equilibrium point C, new steady-state relative prices of nontraded goods in both economies are lower than their initial values. The world capital stock is also unambiguously lower. The lower cost of investment and higher net returns offset the effect of a higher real interest rate on world equity prices.

A question remains as to what happens to this two-country world if the rate of time preference rises in only one economy. Suppose that the domestic rate of time preference, therefore, the real interest rate, rises above the foreign level. The foreign fund will shift from foreign bonds and equities to domestic bonds. Since the government finances its fiscal deficit by taxation and bond issues, according to equation (3.18), and since the foreign bonds are not attractive to investors at a lower foreign interest rate, the foreign government has to finance its debt by raising taxation. This means that the net income of foreign residents is expected to fall permanently. Foreign households will then consume less, which implies that they will use a higher rate of time preference to discount their future income. Consequently, the foreign rate of time preference will have to rise too. The equalization between the rates of time preference, therefore the steady-state real interest rates of different economies, is thus ensured by the international mobility of capital.

The above discussion predicts that an increase in the steady-state real interest rate in one or both economies will inevitably lead to immediate and proportional decrease in equity prices worldwide. This is a situation where a strong correlation of world equity markets is expected.

5. Concluding Remarks

To summarize this chapter, the analytical results of the model suggest the following

First, macroeconomic news, preannounced or unanticipated, permanent or transitory, usually induces overreactions of equity prices. In this model, the overreaction is attributable to the fact that the capital stock cannot change in the short run, thus forcing greater adjustment in the equity price in the short run than is required in the long run to restore the equity market equilibrium.⁴⁴ This explains, from one aspect, the volatility of world equity markets

Second, symmetric policy changes from two similar large economies affect their equity markets and investments absolutely but not relatively.

Third, the distributional effects of an asymmetric policy change estimated with Aoki's technique suggest that policy innovations have unambiguous effects on the equity market and capital accumulation at home. However, its effects on the equity price and capital accumulation abroad are *a priori* ambiguous. The ambiguity is attributable to the fact that an economic innovation at home affects the absolute and the relative economic fundamentals in the same directions for the home economy, but in different directions for the other economy. If the effect on relative fundamentals dominates, the innovation will not induce a one-to-one comovement among the major equity markets. As demonstrated in Section 2, an asymmetric fiscal expansion affects underlying fundamentals of different economies in opposite directions, thereby creating a negative correlation between their equity markets. Or as shown in Section

⁴⁴ This proposition is not to contest the notion that the overreaction of equity markets is due to market imperfection, but instead to provide another explanation of this overreaction.

3, the effect of an asymmetric tax reduction is spilled over to the other economy over time, thereby inducing less significant or lagged reactions from the other equity market in the short run. These results provide explanations as to why evidence does not strongly suggest correlations among world equity markets in the short run and why the world equity return differentials cannot be offset systematically by exchange rate fluctuations.

Fourth, deviations of the world equity price differential from its equilibrium produced by economic innovations will vanish eventually due to the repercussion effects of economic activities and portfolio adjustments. This suggests that a cointegrating relationship based on the long-run fundamentals exists between equity markets. The integration of international equity markets therefore holds on average in the long run.

Fifth, since in the short run, international financial markets do not experience perfect comovements, investors can reduce risk by internationally diversifying their portfolio.

Sixth, the results of this chapter have characterized theoretically the macroeconomic mechanisms that transmit economic "news" across different equity markets. Nevertheless, the results may only partly explain movements and comovements of world equity markets. Given that many kinds of innovations, economic or noneconomic, may provoke fluctuations in equity prices, no single model, no matter how sophisticated it is, can exhaust the explanations of the stylized facts in international equity markets.

CHAPTER V

AN EMPIRICAL INVESTIGATION OF THE INTEGRATION OF INTERNATIONAL EQUITY MARKETS

1. Introduction

To this point, the theoretical model has identified international transmission mechanisms for economic innovations across equity markets. It has also formally characterized two important aspects of the nature of the international equity market integration. In the short run, world equity returns diverge from one another because innovations in fundamentals of one economy may affect the world major equity markets differently, or even negatively. However, the long-run cointegrating relationships exist among world equity markets based on their underlying economic fundamentals.

This chapter will examine whether the analytical results of the model are approximately consistent with the data. Given the complicated structural relationships among the underlying variables, however, the theoretical model discussed in previous chapters cannot be empirically implemented directly. Besides, like many existing theoretical studies that model the nature of financial markets, the theoretical model developed in the current dissertation cannot encompass all of the explanations for the stylized facts of world equity markets. Therefore, even if exact empirical implementation is possible, its results may not be satisfactory because it is impossible for the data to rule out alternative explanations.

To overcome these obstacles, the chapter will use time series models to investigate empirically the characteristics of correlations among world equity markets. Specifically, the empirical study intends to examine (1) the degree and the nature of correlations among world equity markets, and (2) the extent to which world equity markets interact in response to innovations in economic fundamentals.

Inspired by Sims (1980), Eun and Shim (1989), Jeon and von Furstenberg (1990),

Schwert (1990), Johnson and Schembri (1990) and Malliaris and Urrutia (1992), to name a few, this empirical study will address the first issue by estimating an error-correction representation of a cointegrated vector autoregression system (VECM). A pure vector autoregression system (VAR) estimates an unrestricted dynamic simultaneous equation system in which each of the dependent variables is related to a set of its own lags and lags of all other dependent variables in the system. The dependent variables in the current model are rates of changes in internationally comparable equity market indexes, which are approximated by the first differences in logarithms of these indexes.

However, a pure VAR in the first differences will be misspecified, according to Engle and Granger (1987), if these internationally comparable equity market indexes are found to be cointegrated with one another as suggested by the theoretical model. The misspecification arises because if an equilibrium relationship exists between variables y_1 and $y_2, \dots, y_n$ such that $y_1 = \beta_2 y_2, \dots, y_1 = \beta_n y_n$, for instance, discrepancies $(y_1 - \beta_2 y_2), \dots, (y_1 - \beta_n y_n)$ also contain relevant information for forecasting $y_{1,t}$. A pure VAR constructed on the first differences only would therefore omit this information.

This misspecification may be amended by adding error-correction terms to the regressions. The error-correction terms employed are the one-period lagged deviation of the equity price differential between different markets from their respective long-run cointegrating relationships. They indicate the directions of adjustments that should be taken by the current equity returns

The VECM is a sensible approach to investigate correlations among world equity markets. Assuming financial market efficiency, equity returns can be viewed as indicators of

expected and actual fundamentals. The VECM constructed principally on the autoregressive equity returns in all the markets estimated may therefore be regarded as an approximation to the reduced form of a true equity market model based on underlying economic structures. However, compared to structural models, the VECM is relatively unrestricted in terms of the dynamic specification so that it can capture statistically complicated dynamic interactions among a number of world equity markets.

Another desirable property of the VECM approach is its ability to characterize from different perspective correlations among world equity markets by producing a wide range of simulations of interactions among world equity markets using time series data. These simulations, such as variance decompositions and impulse response analysis, reveal the direction and magnitude of the movement in one equity market produced by the orthogonized innovations in another market.⁴⁵

To investigate the behavior of world equity markets in response to economic innovations, an event-study analysis will be performed using a multivariate seemingly unrelated regression system (SUR). Such a model estimates the impacts of economic innovations on rates of changes in equity prices over one-day or two-day event-window. Magnitudes of changes in different markets due to a particular event are measured by the coefficients of event-window dummy variables. Empirical studies have often adopted this

⁴⁵As mentioned in Chapter II, time series models, the family of VAR models in particular, have received severe criticism for their lack of theoretical foundations (see Cooley and LeRoy (1985) for a critical review of this literature). Because such atheoretical models do not depend on prior theoretical restrictions, applications of time series models in macroeconomic studies, as frequently pointed out, may not provide much insight as to the nature of a relationship between the underlying variables.

However, given the foregoing advantages of the VECM, the VECM may be considered as a good complement to the theoretical model.

approach to assess the responsiveness of equity markets to economic innovations. Previous studies using this method include Brown and Warner (1985), Hartigan et al. (1986), Grossman and Levinsohn (1989), Bailey (1990), Peterson (1990), Cornett and Tehranian (1990) and Thompson (1993a, 1994b), to name a few.

Like the VECM model, the SUR approach enables event studies to be relatively free of the possibility of model misspecification. However, in contrast to the VECM model, the SUR model can discern causal relationships between economic fundamentals and equity market movements by regressing rates of changes in equity prices on specific economic events

The remainder of this chapter is organized as follows. Section 2 contains a brief statistical analysis of the stylized facts of the U.S., U.K. Canadian and Japanese markets using both local-currency-denominated and dollar-denominated time-series daily data. Section 3 discusses the methodology and preliminary results of the VECM estimations. Section 4 discusses the methodology of the event study and examines the effects of seven important economic events on the four equity markets to determine the significance of fundamentals on world equity market comovements. The results from the different empirical analyses are summarized and compared in the last section.

2. Stylized Facts of World Equity Markets

In order to obtain some perspective on the correlations among the four major equity markets, it is useful to start the investigation by briefly examining some stylized facts of the movements in these markets during the period of 1985-93.

The data used in the study consists of daily closing values of the Financial Times SE-100 (FT100), the Standard & Poor's 500 Composite Index (S&P500), the Toronto Stock Exchange 300 Composite (TSE300) and Japan's Nikkei 225 (Nikkei225). Each of these composite indexes is a weighted average of a large number of firms listed on the domestic equity market and thus represents the value of a very much diversified portfolio. To examine the effect of exchange rate volatility on movements in these indexes, the statistical analysis will compare movements in these indexes denominated in local currencies and in U.S. dollars.

The period of analysis goes from January 1, 1985 to December 31, 1993, with a total of 2332 observations in each time series. Market characteristics in three three-year subperiods will also be examined and compared.

2.1. Behavior of world equity markets (in terms of local currencies)

A starting point for the statistical analysis is to examine the time trends and the volatility of the four indexes. Given the large sample size, it is difficult to graph daily time series data over a nine-year period. Therefore, monthly average end-of-day indexes in local currencies are calculated and presented in Figure 5.1.

Evidently, both S&P500 and FT100 moved consistently upward throughout the period, showing considerable resemblance in their time trends, except during the first half of 1992. TSE300 also displays a similar trend up to the early 1991. However, instead of moving up continuously along with the U.S. and U.K. markets, the Canadian market cycled during March 1991 to December 1992. All three markets took drastic plunges in October 1987 when world equity markets crashed. Unlike the above three markets, the time trend of the Japanese

Figure 5.1: Monthly Average Equity Price Indexes, in Local Currencies, 1985--1993

Figure 5.2: Monthly Equity Price Changes, in Local Currencies, 1985–1993

market exhibits a dome-shaped curve that peaks at the beginning of the 1990s

Monthly rates of changes based on monthly average indexes are graphed in Figure 5.2 to illustrate the volatility of the four equity markets. A distinct feature of the fluctuations in these markets is that they do not display any apparent pattern. They do, however, exhibit some similarities to each other. Statistics reveals that during the nine-year period, coincident increases or decreases in all four markets occurred in forty months. Given the sample of one hundred and seven months, this means that they have experienced comovement about 38 percent of the time. As shown in Figure 5.2, some movements in these markets seem to be identical in timing and similar in magnitude.

Summary statistics for daily changes in these indexes are reported in Table 5.1. Each of the four panels contains statistics of a different period. While differing in a number of respects, all four markets experienced their deepest falls (indicated by the minimum value of the rates of changes) during 1985-87.

The standard deviation of the rates of change in the U.S. and Canadian markets have declined over each subsequent three-year subperiod. In contrast, the standard deviation of the Japanese market has increased, indicating that the market has become increasingly volatile in more recent years. The pattern of volatility for the U.K. market is less clear, though the market appears to be at its most volatile state in the first subperiod.⁴⁶

Distributions of rates of changes in the four indexes are all negatively skewed to the left for the full period and mostly negatively skewed for the first two subperiods, indicating

⁴⁶The time-varying nature of the variances in these equity markets indicates the existence of ARCH effects in the variances. See Chapter 2, Section 3 for a brief discussion about ARCH/GARCH models in empirical studies.

Table 5.1. Statistics of Equity Market Daily Changes, in Local Currencies,* 1985-1993

	MEAN	STD DEV	MIN	MAX	SKEW	KURT	Correlations between rates of changes			
							FT100	S&P500	TSE300	NIKKEI225
FT100	0.04421	1.00570	-13.029	7.597	-1.710	23.704	1			
S&P500	0.04449	1.04850	-22.900	8.709	-4.813	104.441	0.38813	1		
TSE300	0.02532	0.71898	-12.009	8.646	-2.446	54.821	0.47560	0.68053	1	
NIKKEI225	0.01763	1.33080	-16.136	12.430	-0.465	16.266	0.29670	0.13211	0.25184	1
FT100	0.04379	1.23460	-13.029	7.597	-2.811	29.205	1			
S&P500	0.05182	1.37260	-22.900	8.709	-6.185	104.987	0.44354	1		
TSE300	0.03577	0.98141	-12.009	8.646	-2.727	46.237	0.61329	0.71266	1	
NIKKEI225	0.08064	1.16230	-16.136	8.892	-3.326	54.024	0.37625	0.12431	0.37373	1
FT100	0.02888	0.85371	-3.207	3.489	-0.158	1.066	1			
S&P500	0.03734	0.97067	-7.008	3.523	-0.898	6.614	0.36934	1		
TSE300	0.00389	0.58501	-3.676	1.929	-0.893	4.440	0.35980	0.70395	1	
NIKKEI225	0.01291	1.28880	-6.827	1.243	0.847	15.132	0.25464	0.11655	0.18014	1
FT100	0.05993	0.88618	-5.153	5.439	0.204	6.075	1			
S&P500	0.04434	0.69129	-3.727	3.664	0.208	3.053	0.28165	1		
TSE300	0.03630	0.49788	-2.500	1.843	-0.010	1.643	0.25143	0.52975	1	
NIKKEI225	-0.04034	1.51530	-6.751	7.275	0.077	2.646	0.27820	0.11935	0.21469	1

* The percentage change is approximated by the first log difference between daily values

that market declines have occurred more than market rises. Statistics of kurtosis indicate that distributions of the rates of changes for these markets have more mass in the tail than a normal distribution with the same variance would have, indicating that there have been many large changes in these markets during the period.

Table 5.1 also contains the correlation coefficient matrix that indicates degrees of pairwise contemporaneous comovements across markets. A correlation coefficient of +1 indicates that changes in the two indexes are identical in timing, magnitude and direction. All correlation coefficients in the table are positive and statistically significant. All pairs of markets, except U.S./Japan, show the highest correlation in the first subperiod when these markets were extremely volatile. Among all pairs of markets, U.S./Canada exhibits the highest contemporaneous correlation, a result attributable to the close economic interdependence between the two neighboring countries. It is also noticeable that the contemporaneous correlation of U.K./Japan is stronger than that of U.S./Japan.

2.2. Behavior of world equity markets (in terms of U.S. dollars)

The asset market equilibrium condition (3.5) indicates that international arbitrage activities by investors worldwide equalize expected real returns obtainable from assets of different economies with identical risk characteristics when expressed in the same currency. Since volatility in the real exchange rate is widely believed to be largely responsible for the observed differences among returns on internationally comparable equities, the effects of the exchange rate on the four equity markets are considered in this section.

All four indexes are first converted into U.S.-dollar-denominated daily indexes, using

daily closing equity market prices and closing spot exchange rates. They are then transformed into monthly average indexes and rates of changes.

Despite some different movements in monthly average equity prices, the dollar-denominated indexes graphed in Figure 5.3 exhibit similar time trends to those shown in Figure 5.1. The similarity between the Canadian indexes of different denominations is particularly apparent for the entire period. This suggests that, over the long run, TSE300 has moved along with the changes in the exchange rate between the U.S. and Canadian dollars and the exchange rate between the two currencies has been relatively stable. The upward trend of the dollar-denominated FT100 has become less apparent since mid-1992, which may reflect the persistent depreciation of the pound sterling during the period. A notable difference between the time trends of Nikkei225 in Yen and in dollars is that the declines in the dollar-denominated Nikkei225 around October 1987 and July 1990 appear to be less pronounced, indicating the appreciation in Yen during the two periods.

Changes in monthly equity prices are illustrated in Figure 5.4 as a comparison to those in Figure 5.2. To facilitate the comparison, monthly rates of changes in different denominations are shown in Table 5.2. A depreciation of the domestic currency against the dollar is suggested if the local-currency-denominated monthly increase (decrease) is greater (smaller in absolute value) than the dollar-denominated increase (decrease), or if the local-currency-denominated monthly change is positive while the dollar-denominated monthly change is negative for the same period.

Figure 5.3: Monthly Average Equity Price Indexes: in U.S. Dollars, 1985-93

Figure 5.4: Monthly Changes in Equity Price Indexes, in U.S. Dollars, 1985-93

Table 5.2. Equity Markets Monthly Percentage Changes

DATE	SP500	FT100		TSE300		NIKKEI225	
		in Pound	in U.S.\$	in CAN\$	in U.S.\$	in Yen	in U.S.\$
02 85	5.40	1.67	-1.30	6.33	-0.95	2.49	-0.02
03 85	-0.81	1.06	3.41	0.21	2.82	3.18	4.06
04 85	0.67	-0.35	10.41	0.66	2.15	-0.34	2.25
05 85	2.37	2.58	2.79	2.05	1.28	1.02	0.95
06 85	2.16	-2.61	0.10	1.49	2.03	1.41	2.51
07 85	1.94	-3.14	4.31	1.63	2.68	0.39	3.51
08 85	-2.20	4.43	4.95	0.74	0.49	-1.74	-0.04
09 85	-2.25	0.32	-1.06	-2.75	-3.45	0.46	0.84
10 85	1.15	2.04	6.27	-2.39	-2.39	2.28	12.70
11 85	6.05	5.93	7.18	5.31	4.57	-1.14	3.98
12 85	4.97	-1.18	-0.77	3.12	1.78	1.74	2.38
01 86	0.45	0.68	-0.82	-1.09	-1.92	0.06	1.41
02 86	5.37	5.74	6.25	-1.50	-1.38	2.92	11.56
03 86	5.91	9.19	12.16	6.33	6.58	7.77	11.88
04 86	2.43	3.13	5.03	3.72	4.72	7.39	9.23
05 86	0.21	-3.63	-2.08	-0.57	0.30	3.85	8.77
06 86	2.87	0.14	-0.65	0.23	-0.74	6.89	6.50
07 86	-2.09	-0.87	-0.84	-2.67	-1.94	3.27	9.02
08 86	2.01	-0.63	-2.10	0.81	-0.00	1.97	5.10
09 86	-2.75	2.38	1.40	0.37	0.61	0.39	-0.23
10 86	-0.38	-1.93	-5.00	-0.25	-0.30	-7.00	-7.61
11 86	3.26	2.74	2.57	0.94	1.07	2.64	-1.81
12 86	1.43	0.12	1.24	-0.01	0.45	7.94	8.68
01 87	6.40	7.59	12.53	6.61	8.09	2.68	7.40
02 87	6.21	8.50	10.03	7.65	9.82	3.85	4.71
03 87	4.11	4.90	9.32	5.97	7.13	7.36	8.83
04 87	-1.08	-1.80	0.42	2.17	2.24	8.57	14.99
05 87	-0.08	9.05	11.52	-1.00	-2.54	4.58	6.19
06 87	4.25	5.45	3.20	-0.94	-0.87	3.88	1.26
07 87	2.89	4.46	3.17	6.08	6.86	-5.24	-8.83
08 87	6.21	-4.66	-5.37	2.66	2.89	5.79	7.86
09 87	-3.25	1.97	4.98	-2.93	-2.16	-0.15	2.57
10 87	-12.08	-9.50	-8.31	-12.90	-12.03	-1.81	-1.80
11 87	-12.55	-20.95	-15.74	-13.46	-14.34	-8.95	-3.34
12 87	-1.65	1.75	5.33	4.79	5.64	0.51	5.02
01 88	3.95	5.45	3.13	1.44	2.98	0.33	1.39
02 88	3.05	-1.11	-3.40	-1.80	-0.47	6.69	5.44
03 88	2.95	3.46	7.84	6.74	8.40	5.76	7.68
04 88	-1.18	-1.13	1.15	1.75	2.90	4.33	6.27
05 88	-2.47	-0.23	-0.46	-3.41	-3.66	2.25	2.32
06 88	5.68	3.64	-1.32	4.58	6.40	1.67	-0.42
07 88	-0.60	0.48	-3.73	0.74	1.59	-0.76	-5.07
08 88	-1.98	-1.39	-1.94	-3.62	-4.77	1.04	0.60
09 88	1.54	-3.09	-3.84	-0.60	-1.02	-1.37	-2.00
10 88	3.59	3.90	7.27	3.31	5.16	-0.55	3.77
11 88	-2.30	-1.29	2.71	-3.10	-4.05	4.74	9.56
12 88	2.03	-2.72	-1.75	1.58	3.45	3.44	3.32
01 89	3.22	6.89	3.93	5.55	5.91	4.79	1.54
02 89	3.01	8.11	6.81	3.10	3.27	2.76	2.58
03 89	-0.44	1.41	-0.89	-0.66	-1.20	-0.15	-2.37
04 89	3.26	-0.40	-1.11	-0.45	0.13	3.98	2.71
05 89	3.86	3.43	-0.86	1.71	1.40	2.30	-1.96
06 89	3.11	0.50	-4.34	3.32	2.78	-1.81	-6.00
07 89	2.52	4.64	9.40	2.71	3.36	1.41	3.78

(To be continued)

(Table 5.2 Continued)

DATE	SP500	FT100		TSF300		NIKKEI225	
		in Pound	in U.S.\$	in CAN\$	in U.S.\$	in Yen	in U.S.\$
08 89	4.44	4.77	3.17	3.21	4.55	2.85	2.47
09 89	0.21	0.97	-0.78	-1.40	-1.88	-0.46	-3.17
10 89	0.02	-7.36	-6.19	0.51	1.18	1.95	4.21
11 89	-2.07	0.15	-0.95	-0.35	-0.03	2.02	0.86
12 89	2.46	6.95	8.49	0.60	1.28	5.82	5.82
01 90	-2.47	0.39	3.92	-2.35	-3.11	-1.91	-2.47
02 90	-2.80	-3.00	-0.44	-3.73	-5.78	-2.54	-3.06
03 90	2.42	-2.08	-6.20	-0.16	1.22	-11.38	-16.04
04 90	-0.09	-2.56	-1.73	-6.00	-4.74	-9.50	-12.29
05 90	3.64	1.79	4.26	-0.45	-1.26	8.85	11.54
06 90	2.83	6.57	8.55	2.24	2.29	1.69	2.06
07 90	-0.11	-0.64	4.99	0.22	1.59	-0.53	2.58
08 90	-8.13	-7.06	-2.50	-3.26	-2.11	-16.38	-15.46
09 90	-4.64	-5.20	-5.99	-5.58	-6.66	-11.09	-5.53
10 90	-2.63	0.52	3.91	-4.65	-4.76	-0.61	-6.47
11 90	2.66	-0.11	1.06	0.27	-0.15	-1.35	-1.04
12 90	4.27	3.56	1.29	3.96	4.24	1.16	-2.18
01 91	-0.99	-2.66	-2.05	-0.90	-0.57	-1.76	-1.70
02 91	11.38	8.10	9.67	7.72	7.85	8.14	10.44
03 91	2.61	7.58	0.13	1.77	1.59	4.95	0.15
04 91	2.07	2.63	-1.71	-0.21	0.09	0.01	-0.13
05 91	-0.44	-0.83	-2.14	-0.80	-0.51	-2.47	-2.91
06 91	0.08	0.25	-4.20	1.57	2.12	-5.02	-6.25
07 91	0.51	1.22	1.33	-0.39	-0.87	-5.25	-4.05
08 91	2.43	2.85	4.83	-0.07	0.27	-2.16	-1.44
09 91	-0.57	0.79	3.18	-2.50	-1.66	1.35	3.17
10 91	-0.08	-1.67	-1.70	-0.10	0.49	6.79	9.79
11 91	-0.25	-2.83	0.30	2.57	2.48	-3.27	-2.19
12 91	0.67	-3.82	-1.12	-3.38	-4.75	-6.39	-5.40
01 92	7.10	4.55	3.68	5.97	5.07	-1.90	0.73
02 92	-0.85	0.92	-0.96	-0.59	-2.78	-1.97	-4.14
03 92	-1.26	-1.89	-4.86	-2.65	-3.49	-5.04	-8.96
04 92	0.01	2.17	4.26	-3.15	-2.79	-13.38	-13.49
05 92	1.82	5.91	8.89	0.23	-0.69	4.00	5.31
06 92	-1.58	-3.55	-1.13	-0.07	0.21	-7.51	-4.18
07 92	1.66	-6.19	-2.93	1.58	1.86	-3.67	-2.82
08 92	0.69	-4.06	-3.00	-1.18	-0.91	-3.28	-3.63
09 92	0.15	4.62	-0.23	0.86	-1.65	15.24	18.74
10 92	-1.45	5.49	-5.59	-5.00	-7.00	-5.61	-4.63
11 92	2.51	4.86	-3.30	1.02	-0.68	-2.07	-4.12
12 92	3.03	2.40	4.13	0.39	0.10	3.39	3.19
01 93	-0.09	0.44	-0.92	0.41	-0.13	-4.21	-5.01
02 93	1.49	1.79	-4.41	3.12	4.53	2.27	5.97
03 93	1.91	2.00	3.67	4.09	5.20	5.88	9.28
04 93	-1.57	-2.06	3.53	2.87	1.61	10.94	15.52
05 93	0.49	-0.26	0.04	4.45	3.89	3.09	5.29
06 93	0.63	1.57	-1.05	2.41	1.63	-2.52	0.02
07 93	-0.17	-0.83	-1.59	0.37	0.22	-0.65	-0.99
08 93	1.53	6.04	5.59	3.26	1.07	3.28	7.01
09 93	1.12	0.17	2.39	-1.24	-1.98	07	-1.76
10 93	1.02	3.20	1.69	3.28	2.64	-2.39	-3.53
11 93	-0.22	-0.35	-1.85	2.52	3.28	-10.74	-11.41
12 93	0.66	6.41	7.51	0.55	-0.51	-3.91	-5.78

The data suggest that exchange rate fluctuations have increased the volatility in these equity markets. For instance, out of 107 months examined, 49, 59 and 62 monthly changes in the U.K., Canadian and Japanese indexes are found to be greater in absolute value when they are denominated in U.S. dollars than when they are denominated in local currencies.

However, during the same period, coincident increases or decreases in all four indexes measured in U.S. dollars have occurred in 42 months compared to 40 months when they are measured in local currencies. Comovements among these markets do not seem to have been affected on average by the currency effect. This result may be attributable to the fact that the effect of unanticipated exchange rate fluctuations on the world equity market comovement is largely averaged out when dollar-denominated daily changes are transformed into monthly average changes.

Statistics about the dollar-denominated daily changes in the four equity indexes are summarized in Table 5.3 as a comparison to the local-currency-denominated daily changes reported in Table 5.1. The most noticeable difference between the movements of the two groups of indexes is the greater volatility in the dollar-denominated indexes, which is indicated by two facts. First, the dollar-denominated daily changes in all three non-U.S. markets exhibit greater standard deviations in all subperiods compared to those reported in Table 5.1. Second, the deepest one-day market falls in Britain and Japan during the crash period are deeper when the indexes are in terms of the dollar, indicating that the declines in these two markets are magnified by their currency depreciations against the dollar.

Furthermore, all of the correlation coefficients among daily rates of changes reported in Table 5.3, except those for U.K./Japan, are less significant compared to those reported in

Table 5.3. Statistics of Equity Market Daily Changes, in U.S. Dollars,* 1985-93

	MEAN	STD DEV	MIN	MAX	SKEW	KURT	Correlations between rates of changes			
							FT100	S&P500	TSE300	NIKKEI225
FT100	0.05513	1.23347	-15.264	7.918	-1.079	13.958	1			
S&P500	0.04449	1.04846	-22.900	8.709	-4.813	104.441	0.29860	1		
TSE300	0.02530	0.79206	-11.870	8.859	-2.017	40.281	0.40445	0.62068	1	
NIKKEI225	0.05264	1.52661	-18.223	12.495	-0.535	13.270	0.35038	0.09859	0.22034	1
FT100	0.10776	1.48337	-15.264	7.918	-1.815	18.356	1			
S&P500	0.05181	1.37262	-22.900	8.709	-6.852	104.987	0.32829	1		
TSE300	0.03806	1.04658	-11.870	8.859	-2.483	38.580	0.53630	0.66200	1	
NIKKEI225	0.17522	1.36063	-18.223	9.248	-2.921	45.713	0.42643	0.06397	0.33303	1
FT100	0.03222	1.04396	-4.255	3.967	-0.215	1.037	1			
S&P500	0.03733	0.97068	-7.008	3.523	-0.898	6.614	0.28362	1		
TSE300	0.01848	0.67105	-3.697	3.077	-0.627	3.395	0.32180	0.62288	1	
NIKKEI225	-0.00161	1.52925	-8.350	12.495	0.530	8.694	0.31075	0.08264	0.13152	1
FT100	0.02560	1.12973	-5.989	6.787	-0.067	4.138	1			
S&P500	0.04434	0.69129	-3.727	3.664	0.208	3.053	0.26161	1		
TSE300	0.01940	0.58291	-2.372	2.136	-0.061	1.203	0.19626	0.47830	1	
NIKKEI225	-0.01519	1.66814	-6.747	7.146	-0.004	2.130	0.32645	0.19953	0.19453	1

* The percentage change is approximated by the first log difference between daily values

Table 5.1 The correlation coefficients between the dollar-denominated U.S. and Japanese changes are not significant at all for the first two subperiods, implying that the negative currency effect on the correlation between these two markets is particularly strong.

2.3. Tests for unit root and cointegration

Another way of analyzing the short-run and long-run behavior of individual equity markets and correlations among them is to test formally whether these indexes have unit roots and whether they are cointegrated. The finding of a unit root in an equity market index indicates that the market movement follows a nonstationary process. However, the nonstationary equity price index may become stationary upon being differenced once, meaning that its rates of changes may fluctuate around some fixed positive mean. Such an equity market index is said to follow the process of the first order integration. Unit root tests, among other things, may help market participants to understand the behavior of the equity price

Unit root tests for the four equity market indexes are conducted through the Dickey-Fuller test procedure, which is formulated in the following OLS estimation:

$$\Delta \ln Q_t = \alpha_0 + \alpha_1 \ln Q_{t-1} + \alpha_2 t + v_t, \quad (5.1)$$

where $\ln Q$ denotes the natural logarithm of an equity price index, the first difference of the logarithm of the index times 100 approximates the rate of change in the index, and v_t is assumed to be Gaussian white noise. The test procedure in (5.1) contains a constant and a time trend. The exact nature of a time series may be easily understood by examining the test

results reported in Tables 5.4(a) and 5.4(b).

Entries in the column "Constant" are t-statistics for the estimated α_0 . Numbers in the column "Time" are t-statistics for the estimated α_2 . A value of α_2 greater than 1.96 in absolute value rejects at a 5 percent level the null hypothesis that the slope of the trend line is zero. Unit root test statistics are DF t-statistics for α_1 . An estimated t-ratio smaller than the critical t-ratio in absolute value is consistent with the null hypothesis that the equity price index is characterized by a unit root process. Test results for the joint hypothesis that an equity price index has a unit root with non-zero drift is suggested by F-statistics smaller than the critical value.

Distributions of test statistics depend on the presence of an intercept and a trend of the time series tested. If an equity index has both α_0 and α_2 significantly different from zero, the critical values of DF t-ratio and F-statistics at a 5 percent level are -3.41 and 6.25 respectively. For an equity price index with a constant significantly different from zero, but without an obvious time trend, the critical values of t-ratio and F-statistics are -2.86 and 4.59 respectively. If an equity price contains neither a constant nor a time trend, the critical value for t-ratio is -1.95.

The test results cannot reject at a 5 percent confidence level the joint hypothesis that FT100 and TSE300 each had a unit root with a non-zero drift and a time trend from 1985-93. The null hypothesis that Nikkei225 had a unit root is also accepted at a 5 percent level. In addition, the dollar-denominated Nikkei225 had a drift, and the Yen-denominated Nikkei225 had a mild negative time trend, the slope of which was different from zero at a 10 percent level. The negative time trend was less apparent in the dollar-denominated Nikkei225. Tests

reject at a 5 percent level the joint hypotheses that S&P500 had a unit root with a non-zero drift, which suggests that S&P has been stationary

None of the three nonstationary indexes had a second unit root. Therefore, they were each individually an $I(1)$ process

One analytical result from the theoretical model discussed in previous chapters is that the integration of world equity markets is a long-run rather than a short-run phenomenon. This conclusion may be supported by the data if the four equity markets are found to be cointegrated.

Cointegration means that the difference between two or more time series is stationary even though these time series are individually nonstationary. Cointegration in the current context suggests that equity prices between two national equity markets may move apart in the short run. However, they will return to an equilibrium differential determined by underlying fundamentals so that they will move in parallel over the long run. Divergences from such equilibrium must be stochastically bounded and diminishing over time.

A test of cointegration is conducted through the test for a unit root in the differences between two time series. If the null hypothesis of a unit root in the differences is rejected, it suggests that the differences are stationary in the long run and the two time series are cointegrated. The differences between two equity indexes are simply the estimated residuals from regressing one market index on another:

$$\ln Q_{t,i} = \alpha_0 + \alpha_1 \ln Q_{t-1,j} + \alpha_2 t + \mu_t. \quad (5.2)$$

To find out whether the equity price differential is stationary, apply the Dickey-Fuller unit

root test to the estimated residuals from (5.2)

$$\Delta \mu_t = \beta \mu_{t-1} + \varepsilon_t \quad (5.3)$$

Results of the cointegration tests for the four equity market indexes denominated in both U.S. dollars and local currencies are presented in Table 5.5(a) and 5.5(b). Each entry in the tables is the Dickey-Fuller t-statistic. The asymptotic critical value for the DF statistic is -3.50 at a 10 percent confidence level. A number greater than 3.5 in absolute value rejects the null hypothesis that the estimated regression residuals contain a unit root, which indicates that the two markets are cointegrated.

Test statistics reported in Table 5.5(a) show evidence of cointegration for S&P500/TSE300 and S&P500/NIKKEI225 when the four equity price indexes are measured in terms of U.S. dollars. There is no evidence of systematic comovements among other dollar-denominated equity price indexes during 1985-93. This result is not consistent with the result of Kasa (1992), which indicates the presence of a single common trend driving the U.S., U.K., Germany, Japanese and Canadian equity markets during the period of January 1974 to August 1990. The inconsistency is mainly attributable to the fact that only nine years of data is used for the current cointegration tests as opposed to seventeen years of data used in Kasa's tests. Cointegration is a long-term concept. The longer the time span is, the more likely that these equity markets will converge to a common trend.

Cointegration test statistics reported in Table 5.5(b) indicate that, when measured in local currencies, four out of six pairs of markets were cointegrated during the period of 1985-93. Since the differential between local-currency-denominated equity price indexes across

Table 5.4 (a). Test Statistics for Unit Roots in Equity Price Indexes in Logarithms, in U.S. Dollars, 1985-93

	Constant	Time	DF t-stats	F-stats
FT100	2.963*	1.976*	-2.881**	5.043**
S&P500	3.602*	3.184*	-3.554	6.580
TSE300	2.168*	0.936	-2.124**	2.671**
NIKKEI225	2.133*	-1.282	-1.637**	4.984**

Table 5.4 (b). Test Statistics for Unit Roots in Equity Price Indexes in Logarithms, in Local Currencies, 1985-93

	Constant	Time	DF t-stats	F-stats
FT100	2.708*	2.455*	-2.680**	3.594**
S&P500	3.602*	3.184*	-3.554	6.580
TSE300	2.376*	1.162	-2.348**	2.862**
NIKKEI225	1.435	-1.803	-1.299**	4.470**

* Estimates that are significantly different from zero at a 5% confidence level.

** The null hypothesis of a unit root cannot be rejected at a 5% confidence level

Table 5.5 (a). Test Statistics for Cointegrations between equity Price Indexes, in Logarithms, in U.S. Dollars, 1985-93

	S&P500	TSE300	NIKKEI225
FT100	-3.3989	-3.1938	-3.2140
S&P500		-3.5445*	-3.6465*
TSE300			-2.8599

Table 5.5 (b). Test Statistics for Cointegrations between equity Price Indexes, in Logarithms, in Local Currencies, 1985-93

	S&P500	TSE300	NIKKEI225
FT100	-6.0399*	-4.0303*	-2.5267
S&P500		-3.5248*	-3.6386*
TSE300			-1.9208

* Cointegration between two equity markets is accepted at a 10% level.

The asymptotic critical value for cointegration test is -3.50 at a 10% level.

markets reflect, among many things, investors' perceptions about exchange rate movements in the future, the cointegrating relationships among local-currency-denominated price indexes of these four markets are also suggestive about the comovements of these markets in the long run

To summarize this section, all four equity markets exhibited significant contemporaneous correlations during the nine-year period when denominated in local currencies. However, the contemporaneous correlations were much less significant for most pairs of market when denominated in U S. dollars, which was largely due to the effect of the exchange rate fluctuations. The correlations were stronger among most markets during 1985-87 when world financial markets were highly volatile. Except S&P500, all equity market indexes are nonstationary. Evidence of systematic comovements is found for some but not all markets.

3. World Effects of Equity Market Innovations, the VECM Estimations

Four VECMs will be estimated in this section. The objective is to characterize the dynamic interactions among the four equity returns in response to innovations in each other

3.1. Methodology

The VECMs estimated are formulated as follows

$$R_t = C + \sum_{i=1}^p \Phi(L)R_{t-i} + B\mu_{t-1} + \varepsilon_t \quad (5.4)$$

$R_t = \ln(Q/Q_{t-1}) \times 100$ is a 4×1 column vector of rates of returns on equity price indexes Q 's.⁴⁷ All four indexes are in terms of local currencies.⁴⁸

Rates of returns, rather than absolute levels, of equity market indexes are chosen as dependent variables for both methodological and economic reasons. Since most of the indexes, as shown in Section 2.3, are nonstationary time series with a time trend, they need to be detrended and made stationary by taking the first log-difference. Besides, since the estimate involves indexes measured in different scales and denominations, only rates of returns can possibly be compared. Most importantly, it is rates of returns on comparable equities that investors worldwide compare and arbitrage.

$\Phi(L)$ indicates a matrix polynomial in the lag operator L . It consists of p number of 4×4 submatrices. The autoregressive coefficients ϕ 's measure the persistence and intensity of the effect produced by an innovation in the equity return. More specifically, each element of the matrix Φ measures the degree of responsiveness of the j th market to changes in the i th

⁴⁷The rate of return to equities is generally defined as

$$R = \frac{Q_{t+1} - Q_t}{Q_t} + \frac{D_t}{Q_t}$$

Since dividend payments do not vary significantly on the daily basis, the second term does not have much effects on daily equity returns. Percentage changes in the equity price indexes will therefore be used to approximate rate of returns in the following analysis.

⁴⁸The empirical test uses data in terms of local currencies because of two reasons.

First, the underlying assumption for using equity returns in local currencies is that the currency premium has been included in equity prices, which is in turn reflected in the systematic equity price differentials among different equity markets. In this sense, equity returns in terms of local currencies may better reflect expectations of exchange rates compared to equity returns in U.S. dollars, and they do not change daily according to random errors in forecasting exchange rates.

Second, as pointed out by Pigott (1993), the currency risk factor is found to be responsible for only a small fraction of *ex post* asset return differentials across economies. Innovations in fundamentals are generally a much more important source of international equity return differentials. In this sense, the estimated results based on daily rates of returns in local currencies are also suggestive and can provide useful insight to the nature of the correlations among these markets.

market in period s

μ_{t-1} is a 4×1 vector of error-correction terms (ECT). The ECTs are the residuals associated with a set of four cointegrated relationships obtained from equations (5.2) and (5.3). There are four cointegrated relationships among six pairs of indexes. Variables $\mu_{1,t-1}$ to $\mu_{4,t-1}$ are the residuals associated with the cointegrated relationships for S&P500/FT100, S&P500/TSE300, S&P500/NIKKEI225 and FT100/TSE300 respectively. Since μ 's are normally distributed with zero means, μ_{t-1} different from zero indicates the one-period lagged deviation from the underlying long-run equilibrium relationship between two equity indexes. B is a 4×4 matrix of coefficients that measure extents of corrections in these equity markets to equilibrium errors.

ϵ_t is a 4×1 vector generalization of white noise⁴⁹ with the following properties

$$E(\epsilon_t) = 0, \quad E(\epsilon_t \epsilon_s') = \begin{cases} \Omega & \text{for } t=s \\ 0 & \text{otherwise} \end{cases}$$

where Ω is a 4×4 symmetric positive definite matrix.⁴⁹ Following the conventional assumption of financial market efficiency, predicted equity returns are supposed to take into consideration all the necessary information. Thus, $\epsilon = R - E[R | R_{t-1}, R_{t-2}]$ is the forecast error.

As an illustration of how the VECM system is formulated, the error-correction representation for a particular equity market may be written as

⁴⁹Statistics in Section 2 indicate the ARCH effects in market variances and nonnormal distributions of returns in these markets. Thus, the ARCH/GARCH approach should yield a more efficient forecast of market variances. The VECM approach is chosen over the ARCH/GARCH approach because of its flexibility in multivariate expansion. However, the choice is made at the expense of losing the gain of efficiency offered by the ARCH/GARCH model in forecasting variances.

$$\begin{aligned}
R_{it} = & C_i + \phi_{i1}R_{1,t-1} + \dots + \phi_{i4}R_{4,t-1} + \phi_{i1}R_{1,t-2} + \dots + \phi_{i4}R_{4,t-2} + \dots \\
& + \phi_{i1}R_{1,t-p} + \dots + \phi_{i4}R_{4,t-p} + b_{i1}\mu_{1,t-1} + \dots + b_{i4}\mu_{4,t-1} + \varepsilon_t,
\end{aligned} \tag{5.5}$$

where $i = 1 \dots 4$ denotes the four markets investigated. Thus the equity return on each individual market is regressed on a constant, p of its own lags, p lagged returns on each of the other three markets, and four error correction terms. Note that each regression has the same explanatory variables.

If the condition for stationarity, $|\Phi| < 1$ holds, repeated substitution for lagged value of R_t in (5.4) yields an infinite MA process of the following form

$$R_t = \sum_{s=0}^q \Psi_s \varepsilon_{t-s} + (C + B\mu_{t-1}), \tag{5.6}$$

where Ψ is a 4×4 matrix of MA coefficients for $s = 1, 2, \dots, q$. In this infinite vector moving average representation, individual rates of returns are expressed as a convergent sum of the history of ε plus other terms. The ij th element of the coefficient matrix Ψ identifies the response of the i th market in s period to one unit of innovations in the j th market.

Since the system (5.6) contains complicated cross-market feedbacks, the coefficient matrix Ψ without decomposition makes it very difficult to interpret. One device to deal with this difficulty is to transform the standard infinite MA process by decomposing the regular vector of forecast errors into a lower triangular matrix A and an orthogonalized vector of

innovations v . Since for any symmetric positive definite matrix Ω , there is a unique triangular matrix A with 1's along its principal diagonal and a unique diagonal matrix Σ with positive elements along the principal diagonal, a 4x4 matrix of orthogonal innovations can be constructed by using the matrix A

$$v_t = A^{-1} \varepsilon_t, \quad (5.7)$$

$$\begin{aligned} E(v_t v_t') &= [A^{-1}] E(\varepsilon_t \varepsilon_t') [A^{-1}]' \\ &= [A^{-1}] \Omega [A^{-1}]' \\ &= [A^{-1}] A \Sigma A' [A^{-1}]' \\ &= \Sigma, \end{aligned} \quad (5.8)$$

where v_t is the vector of orthogonalized innovations. v_t is serially uncorrelated because ε_t is serially uncorrelated. Besides, the elements of v_t are mutually uncorrelated because Σ is a diagonal matrix.

Pre-multiplying Equation (5.7) by matrix A yields

$$\begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ \alpha_{21} & 1 & 0 & 0 \\ \alpha_{31} & \alpha_{32} & 1 & 0 \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & 1 \end{bmatrix} \begin{bmatrix} v_{1t} \\ v_{2t} \\ v_{3t} \\ v_{4t} \end{bmatrix}. \quad (5.9)$$

If a unit shock to the first equity market occurs at time t , the orthogonal vector of innovations is then given by

$$[v_{1t} \ v_{2t} \ v_{3t} \ v_{4t}]' = [1 \ 0 \ 0 \ 0] , \quad (5.10)$$

and equation (5.9) can be written as

$$\begin{bmatrix} \epsilon_{1t} \\ \epsilon_{2t} \\ \epsilon_{3t} \\ \epsilon_{4t} \end{bmatrix} = \begin{bmatrix} 1 \\ \alpha_{21} \\ \alpha_{31} \\ \alpha_{41} \end{bmatrix} \quad (5.11)$$

Apparently, all four markets are subject to the innovation that occurs in the first market.

Analogously, when a unit innovation shocks the second market, each of the remaining markets will be affected in the following way:

$$[v_{1t} \ v_{2t} \ v_{3t} \ v_{4t}]' = [0 \ 1 \ 0 \ 0] , \quad (5.12)$$

$$\begin{bmatrix} \epsilon_{1t} \\ \epsilon_{2t} \\ \epsilon_{3t} \\ \epsilon_{4t} \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \\ \alpha_{32} \\ \alpha_{42} \end{bmatrix} . \quad (5.13)$$

Unlike the situation in which a shock to the first market affects all markets, a shock to the second market does not influence the first market. It will soon become clear that this special feature is important: when the influence of one market on the rest of the markets needs be tested

The above examples show that obtaining orthogonalized impulse responses of different markets involves decomposing the original innovations, $\epsilon_{1t}, \dots, \epsilon_{4t}$, into a set of uncorrelated components $v_{1t}, \dots, v_{4t}$ and then calculating the effects of a normalized impulse in v_{it} on R_t of all four markets

3.2. Model specifications

The three crucial tasks in VECM specifications are the choice of variables, which have been considered in the previous part of this chapter, the choice of the number of lags and the ordering of regression

The number of lags, p , has to be sufficient to summarize all the dynamic correlations among elements in the multivariate system, but not too many to include lags that are not necessary. The following VECM systems are estimated with 21 autoregressive lags of each dependent variable. This is equivalent to estimating 84 (4×21) coefficients for lagged returns in each equation and 336 (4×84) coefficients in the system. Intuitively, the choice of 21 lags is reasonable since 21 trading days constitute approximately one month, long enough to assess the short-term comovements of the four markets. Tests of the same VECMs with less than 21 lags have also been conducted. The results reject the hypothesis that coefficients of higher order lags are zero at 5 percent significance level, and increasing the number of lags to 21 improves more than marginally the collective explanatory power of lagged variables.

Since the four markets are located in different time zones, they do not operate simultaneously. Among them, the Japanese market is the first to open, from 8:01 P.M. to 2:00 A.M. eastern time, followed by the U.K. market, operating from 4:31 A.M. to 10:30 A.M.

eastern time. The U.K. market has a sixty-minute overlapping trading hour with the U.S. and Canadian markets, which trade concurrently from 9:31 A.M. to 4:00 P.M.⁵⁰

In estimating the VECMs formulated in Section 3.3.1, the trading day starts from the U.K. market, which is arbitrary. However, for variance decomposition, or innovation accounting in Section 3.3.2, different orderings are used. This is necessary because an important property of the exercise of variance decomposition (using the method of Choleski factorization) is that the result is sensitive to the ordering of regressions. Equations (5.9)-(5.13) show that an innovation to the market that opens first may be observed and followed by all the rest of the markets, while an innovation occurred in the market that opens last does not influence other markets on the same trading day. Consequently, a market that opens last will have more of its variances attributable to innovations in other markets than if it opens first. To ensure that conclusions from variance decomposition process are not based on any *a priori* assumption and are robust to ordering, the exercise is performed for trading days that starts from the U.K., U.S. and Japanese markets in turn.

Non-synchronizing national holidays present a difficulty in using daily data. Over nine years of sample period, there are 47, 56, 63 and 118 holidays, excluding Christmas Day and New Year's Day, for the U.K., the United States, Canada and Japan respectively. In the financial world where innovations are often transitory, one or two days could be enough for

⁵⁰Three factors may result in different estimations of the trading overlap between the London and the North American markets. First, the legal closing for the London market is 3:30 P.M. London time while the official closing is 5:00 P.M. Second, daylight saving time began one month earlier in the United Kingdom than in the United States before 1987 but only one week earlier since 1987. Third, the North American markets opened at 10:01 A.M. until September 30, 1985, and at 9:31 A.M. thereafter. Thus, the trading overlaps estimated by different empirical studies may vary depending on which closing time used and which period examined. Here the legal closing is used so that the trading overlap between London and New York is one hour after 1987.

markets to complete adjustments. Being closed for one to several days, a market may have either enough time to process the new information so as not to overreact, or may not have a chance to react to the news at all. This reduces the accuracy of estimation using daily data. In the following VECM estimations, the market value of a holiday is the closing value of the previous trading day and thus the rate of return on the holiday is zero.

The program used for the empirical estimation is TSP.

3.3. Discussion of preliminary empirical results

Four VECMs are estimated to encompass the period of 1985-93 and three subperiods that are 1985-87, 1988-90 and 1991-93 respectively.

3.3.1. Estimates of VECMs

Since the family of vector autoregressive models presumes that a structural relationship exists among the variables considered, the significance of coefficients in these models are no longer used to judge the existence of such relationships. Instead, the focus of the examination is on the effects of innovations in one market on other markets and whether the effects are mutual or unidirectional.

Table 5.6 presents selected estimates of equation (5.4). Eq. UK, Eq. US, Eq. CAN and Eq. JAP, each explaining one market, are the four OLSQ regressions in each VECM system. To save room, only the sum of the 21 autoregressive coefficients for each dependent variable and the sum of all 4x21 autoregressive coefficients of each regression in a VECM are reported. For instance, the sum of the coefficients for the 21 lagged returns on FT100 is 36.8

for Eq UK in VECM1. During the same period, the sum of the coefficients for the 21 lagged returns on S&P500 is about 43.6 for Eq UK, and so on. A summation of 21 autoregressive coefficients with a plus sign implies that the positive relationship between the current return in the estimated market and the 21 past returns in another market outweighs their negative relationship. The number to the right of the summation indicates the number of coefficients in each group of the 21 autoregressive coefficients that are statistically significant at a 10 percent level.

The estimates reported in Table 5.6 show that the current return in each market can be partly predicted by previous returns in other markets. If these previous returns reflect expectations based on past economic fundamentals, the result suggests that fundamental innovations in these markets usually produce persistent effects on each other.

Among these markets, previous U.S. returns are systematically the most significant in predicting current returns of other markets. They usually explain more of a market than other foreign markets can do collectively. A notable exception is found in the period 1990-93 (see VECM3) when previous U.K. returns are more significant than U.S. returns in explaining other markets. Besides, the sums of the 21 autoregressive U.S. returns are in general positive, indicating that positive relationships between past U.S. returns and current returns in other markets are dominating. In contrast, previous returns of other markets are much less influential to the current U.S. return, which is suggested by the negative or insignificantly positive sums of coefficients for the 21 autoregressive returns in these markets for Eq US in all VECMs.

Among the four markets, impacts of past U.S. returns on the current U.K. and

Japanese returns are generally substantial. The U.K. and the U.S. markets seem to be closely linked and the relationship is stable. The strong impact of the U.S. on Japanese markets, however, comes from two or three past U.S. returns only. The coefficients decay very fast (not shown in the table) and the lagged U.S. returns beyond the first five days are not significant at all. This may suggest that the impact of U.S. market innovations are short-lived where the Japanese equity market is concerned.

The opposite occurs to the relationship between the U.S. and Canadian markets. The sum of the 21 previous U.S. returns is 0.295 for Eq. CAN of VECM1, which is smaller than that of 0.439 for Eq. UK or 0.419 for Eq. JAP of VECM1. Results are similar for VECM2. However, out of the 21 previous U.S. returns in Eq. CAN of VECM1, twelve are statistically significant, which indicates that the effect of the U.S. market on the Canadian market tends to persist.

The seemingly less strong impact of the U.S. past returns on the Canadian market is largely attributable to the fact that the two markets trade concurrently. Therefore, a considerable amount of interaction between the Canadian and U.S. markets is contemporaneous, which is why the two markets have shown the most significant contemporaneous correlations. The U.K. and Japanese markets, on the contrary, open before the U.S. market. They are therefore expected to have less significant contemporaneous correlations with the U.S. market but stronger reactions to the first lagged U.S. return. Besides, Canadian investors may have better information about the U.S. market. Therefore, they tend to less overreact to innovations in the U.S. market.

Table 5.6: Estimates of Four 21st-Order VECMs Using Daily Returns

	VECM1(1985-93)		VECM2(1985-87)		VECM3(1988-90)		VECM4(1991-93)	
EQUK	Coef*	#t-stat	Coef	#t-stat	Coef	#t-stat	Coef	#t-stat
FT100 (-1 to -21)	0.368	8	0.514	5	0.520	5	0.392	9
S&P500 (-1 to -21)	0.439	7	0.546	7	0.155	4	0.634	2
ISE300 (-1 to -21)	-0.199	5	-0.326	7	-0.078	3	-0.353	3
Nikkei225 (-1 to -21)	-0.088	5	-0.196	3	-0.056	3	-0.012	5
Total of 4x21 lags	0.520	25	0.538	22	0.542	15	0.660	19
ECT1**	-0.171		0.298		-0.048		-0.291	
ECT2	0.177		-0.258		0.089		0.281	
ECT3	0.014		-0.014		-0.012		0.002	
ECT4	-0.161		0.181		-0.091		-0.242	
R2	0.216		0.412		0.217		0.199	
F-Statistics	7.132		5.131		1.966		1.836	
DW	2.000		1.989		1.991		1.999	
EQU'S								
FT100 (-1 to -21)	0.048	6	0.010	8	0.243	4	-0.104	2
S&P500 (-1 to -21)	-0.008	7	-0.123	6	-0.055	3	0.556	2
ISE300 (-1 to -21)	-0.022	5	0.242	3	-0.178	3	-0.006	2
Nikkei225 (-1 to -21)	-0.061	1	-0.310	1	0.033	2	-0.130	1
Total of 4x21 lags	-0.044	19	-0.182	18	0.043	12	0.316	7
ECT1	-0.124		-0.487		0.965		-0.685	
ECT2	0.118		0.469		-0.900		0.661	
ECT3	-0.001		0.028		-0.088		-0.054	
ECT4	-0.946		-0.372		0.731		-0.518	
R2	0.081		0.215		0.146		0.137	
F-Statistics	2.195		2.118		1.339		0.873	
DW	1.995		1.987		1.994		1.993	
EQU CAN								
FT100 (-1 to -21)	-0.039	9	0.104	9	0.135	3	-0.267	2
S&P500 (-1 to -21)	0.295	12	0.394	8	-0.012	2	0.611	3
ISE300 (-1 to -21)	0.195	6	0.255	3	0.325	3	0.173	5
Nikkei225 (-1 to -21)	0.014	4	-0.316	2	0.038	3	0.052	3
Total of 4x21 lags	0.465	31	0.437	22	0.487	11	0.568	13
ECT1	-0.069		0.332		1.031		-0.417	
ECT2	0.095		-0.275		-0.931		0.388	
ECT3	-0.003		-0.042		-0.098		-0.005	
ECT4	-0.051		0.245		0.773		-0.307	
R2	0.174		0.366		0.166		0.207	
F-Statistics	5.228		4.893		1.279		1.066	
DW	1.999		1.986		1.994		2.012	
EQU JAP								
FT100 (-1 to -21)	0.298	2	0.068	1	0.842	2	0.571	5
S&P500 (-1 to -21)	0.419	3	0.420	2	0.267	3	-0.017	2
ISE300 (-1 to -21)	-0.236	1	-0.092	0	-1.126	3	0.456	2
Nikkei225 (-1 to -21)	0.046	7	-0.238	4	0.361	6	-0.003	4
Total	0.527	13	0.157	7	0.344	14	1.006	13
ECT1	-0.165		-0.746		-3.155		-0.756	
ECT2	0.161		0.717		2.922		0.731	
ECT3	0.017		0.062		0.259		0.018	
ECT4	-0.137		-0.579		-2.426		-0.581	
R2	0.153		0.400		0.257		0.133	
F-Statistics	5.245		6.167		2.073		1.172	
DW	2.061		1.998		1.993		2.002	

* Entries under coef are sums of 21 autoregressive lags of each dependent variable, or 4x21 autoregressive lags in each regression. Entries under #t-stat indicate the number of the 21 coefficients that are significant at a 10% level.

** Entries greater than 1.645 and 1.96 in absolute value are significant at 10% and 5% levels respectively.

It is also noted that the U K market has had a stronger influence on the Japanese market since 1987. A possible explanation is that Japan has gradually relaxed its restrictions on capital movement since the 1980s, which has greatly increases the exposure of the Japanese equity market to the influence of the European equity markets.⁵¹

Information about the collective predictive power of all independent variables is contained in three statistics: total sums of 4x21 autoregressive coefficients for individual equations, R-squares, and F-statistics. Evidently, the sums of 4x21 autoregressive coefficients for Eq. UK, Eq. CAN and Eq JAP are all positive and substantial, while those for Eq US are either relatively smaller or negative.

Also noted is that coefficients of determination, R^2 's, are not generally high, those for Eq US in particular. This indicates that many movements in daily equity returns are not explained by a simple autoregressive time series model. However, it is worth noting that, R^2 's for all regressions in VECM2 (1985-87) are much higher, which coincides with a period of greater market volatility. This result is consistent with those obtained by Bennett and Kelleher (1988), Dwyer and Hafer (1988), Schwert (1990) and King and Wadhwani (1990), to name a few. They all find that correlations among equity markets tend to be the highest when world markets are the most volatile.

Information of the collective predictive power of all independent variables in a regression, or block exogeneity tests in the time series analysis, is contained in F-statistics,

⁵¹Over the 1980s, Japan underwent a series of deregulations that removed controls on capital flows. The revision of the Japanese Foreign Exchange Law in the end of 1980 allowed many types of transactions with foreign countries and foreign residents to invest in the Japanese equity market. In mid 1984, Japan removed its limitations on the exchange between foreign currency. Yen-denominated foreign loans were deregulated. In 1987, the Japanese bond market was further deregulated. See Campbell and Hamao (1992) for details.

which indicate whether the 4x21 lagged values of all dependent variables as a whole Granger-cause the current return in a market ⁵² For the current sample, a F-statistic greater than +1 means that we should reject the null hypothesis at a 5 percent level that the lagged returns are not significant in predicting the current return in the estimated market. The estimated F-statistics are all greater than 1, except Eq US of VECM4. Besides, F-statistics for Eq US are usually the lowest for all four VECMs. This suggests that the U S market is more exogenous in the time series sense.

Table 5.6 also contains estimated coefficients ECT1 to ECT4 for the four error-correction terms. ECT1 to ECT3 in Eq US are expected to have opposite signs to ECT1, ECT2 and ECT3 for Eq UK, Eq CAN and Eq JAN respectively. If the differential between the U S index and each of the other three indexes in the last period is greater than the respective equilibrium differential, the current U.S. equity price is expected to fall and the current price of the other market is expected to rise. ECT4 and ECT4 are expected to have opposite signs for Eq UK and Eq CAN respectively.

The test statistics show that only 25 percent of the estimated adjustments to the error-

⁵²The concept of exogeneity is related to causality tests. The idea of causality was first formalized by Granger (1969). The essence of causality is that x causes y if taking account of past values of x leads to reductions in the forecast error given all relevant information. Stated formally:

$$MSE [E(y_{t+h} | y_t, y_{t-1}, \dots, x_t, x_{t-1}, \dots))] < MSE [E(y_{t+h} | y_t, y_{t-1}, \dots)]$$

where MSE is the mean squared error of a forecast of y. If including past values of x does not lead to improved predictions for y, y is said to be exogenous in the time series sense with respect to x. In the present context, if lagged rates of returns of other equity markets take on zero coefficients in predicting the current return on a market, they fail to Granger-cause the changes in that market. The market is then said to be exogenous to past returns of all other markets.

For further discussion on exogeneity, see Engle *et al.* (1983).

correction terms are statistically significant, which suggests that corrections in these markets to errors in the previous period have generally been partial.⁵³ This result is consistent with the dynamics of the world difference system discussed in Chapters III and IV. The theoretical analysis demonstrates that an innovation in fundamental determinants of equity returns generally produces an overreaction of the equity price differential from its long-run equilibrium. The adjustment of the equity price differential after the overreaction is a gradual process that follows a gradual change in the capital stock.

Table 5.7 contains correlation coefficients between residual returns of different markets estimated from equation (5.4). All coefficients, except that for U.S./Japan during 1985-87, are positive and significant, suggesting considerable contemporaneous interreactions to variances in the four markets.

3.3.2. Innovation accounting and impulse response analysis

Evidently, estimates reported in Table 5.6 exhibit significant and complicated cross-market feedbacks. To determine the exact directions and magnitudes of these feedbacks, proportions of forecast errors of each market produced by the orthogonalized innovations in other markets are estimated. The exercise, as formulated in equation (5.9), is called variance decomposition or innovation accounting.

⁵³However, the estimation using local-currency-denominated data may not reflect the true market behavior. When daily changes in foreign exchange markets are considered, the one-day disequilibrium may be changed, which will result in different reactions from each market. To compare results, four VECMs based on the dollar-denominated data are also estimated. The estimates for ECT's are improved to some extent where the signs are concerned. Nevertheless, there is still a large percentage of the dollar-denominated error-correction coefficients that are statistically insignificant.

Table 5.7: Correlation Coefficient Matrices of Residual Returns*

1985-1993				
	FT100	S&P500	TSE300	NIKKEI225
FT100	1			
S&P500	0.38710	1		
TSE300	0.39897	0.69247	1	
NIKKEI225	0.20254	0.11656	0.16694	1
1985-1987				
	FT100	S&P500	TSE300	NIKKEI225
FT100	1			
S&P500	0.43210	1		
TSE300	0.48023	0.73220	1	
NIKKEI225	0.19482	0.06657	0.18316	1
1987-1990				
	FT100	S&P500	TSE300	NIKKEI225
FT100	1			
S&P500	0.39064	1		
TSE300	0.33007	0.71036	1	
NIKKEI225	0.19264	0.11847	0.16881	1
1991-1993				
	FT100	S&P500	TSE300	NIKKEI225
FT100	1			
S&P500	0.28128	1		
TSE300	0.20148	0.51260	1	
NIKKEI225	0.22870	0.21234	0.17153	1

* The ij th entry in the table is the correlation coefficient of residual returns between each pair of markets estimated from the VECMs using daily data

Table 5.8 presents the estimates of the full-period VECM. Each column in the table contains percentage variances or forecast errors in one market produced by the innovation in another market at the 2-day to 21-day horizons. Variances in each market produced by collective foreign innovations are reported in the last column. There are three panels in the table, each containing outputs of a different ordering of factorization.

The estimated results show that no market is strictly exogenous in the sense that its variance is accounted for by its own innovations only. This holds for different orderings. The variance of each market is partly explained by innovations in other markets. For instance, the U.K. market has about 11.6 percent of its variance explained by foreign markets when it is assumed to open first. The proportion increases to 15 percent and then 29.47 percent as it moves back on the ordering. The U.S. market is the least affected when it is assumed to open first. Still, about 1 percent to 5 percent of its variance, depending on various time horizons, is not produced by its own innovations. Collective effects of foreign market innovations become more important to each market over longer time horizons.

Nevertheless, with the exception of Canada, the total amount of variance in each market explained by all foreign markets within a month period is small. This suggests that these markets, to various extents, move on their own.

Once again, the U.S. equity market appears to be the main source of external influence on other markets. Innovations in the U.S. market invariably explain a greater portion of the variance in any market than the other two foreign markets can do together. U.S. innovations explain, depending on different orderings and time horizons, about 39 to over 51 percent of the variance in the Canadian market, 10 to 25 percent of the variance in the U.K. market, and

3 OF/DE 3

PM-1 3½"x4" PHOTOGRAPHIC MICROCOPY TARGET
NBS 1010a ANSI/ISO #2 EQUIVALENT

PRECISIONSM RESOLUTION TARGETS

Table 5.8: Equity Market Variance Decompositions:* 1985-1993

Market Explained	k	Percentage variance accounted by					FM**
		UK	US	CANADA	JAPAN		
UK	2	88.380	10.598	0.266	0.756		11.620
	10	85.253	11.987	0.996	1.764		14.747
	21	83.562	12.842	1.725	1.871		16.438
US	2	15.174	84.642	0.110	0.074		15.358
	10	15.475	83.323	0.800	0.402		16.677
	21	15.620	81.987	1.505	0.888		18.013
CANADA	2	14.707	39.367	45.455	0.471		54.545
	10	14.556	40.156	44.538	0.750		55.462
	21	14.921	39.429	44.139	1.511		55.861
JAPAN	2	5.205	8.600	0.787	85.408		14.592
	10	5.552	8.957	1.015	84.476		15.524
	21	6.327	9.057	1.528	83.088		16.912
		US	CANADA	JAPAN	UK		FM
US	2	99.037	0.249	0.153	0.561		0.963
	10	96.816	1.068	0.520	1.596		3.184
	21	95.068	1.779	0.928	2.226		4.932
CANADA	2	51.799	47.288	0.608	0.306		52.712
	10	51.658	46.486	0.953	0.903		53.514
	21	50.426	46.182	1.597	1.795		53.818
JAPAN	2	11.186	1.376	87.425	0.014		12.575
	10	11.426	1.635	86.474	0.465		13.526
	21	11.553	2.119	85.125	1.203		14.875
UK	2	23.574	3.323	2.579	70.524		29.476
	10	24.316	3.858	3.492	68.334		31.666
	21	24.550	4.673	3.573	67.204		32.796
		JAPAN	UK	US	CANADA		FM
JAPAN	2	89.853	1.556	8.511	0.081		10.147
	10	88.973	1.895	8.853	0.279		11.027
	21	87.671	2.589	8.939	0.801		12.329
UK	2	4.026	84.953	10.831	0.190		15.047
	10	4.813	82.047	12.232	0.908		17.953
	21	4.990	80.346	13.056	1.608		19.654
US	2	1.489	13.905	84.512	0.094		15.488
	10	1.803	14.233	83.228	0.736		16.772
	21	2.218	14.473	81.871	1.439		18.129
CANADA	2	2.728	12.990	39.181	45.101		54.899
	10	2.937	12.888	40.034	44.142		55.858
	21	3.603	13.369	39.265	43.763		56.237

* The ij th entry represents the portion of forecast error of the i th market on a k -day horizon produced by an innovation in the j th market today

** Total amount of variance produced by foreign markets

9 to 12 percent of the variance in the Japanese market. This result is similar to those found by other recent studies, such as Schollhammer and Sand (1987) and Eun and Shim (1989).

The portion of the variance in the Japanese market explained by other markets does not change much. Its variances are generally the least important to other markets, no matter whether the Japanese market is assumed to be the first or the last to open.

Next, consider a different method of dynamic simulation to assess the degree of correlation and the speed of interaction among the four equity markets. Table 5.9 contains results produced from simulations for responses of these equity markets to a normalized innovation (by setting the residual to +1 at time t and 0 thereafter) during 1985-93. The estimates reported in the four panels show how much each of the four markets reacts at different time horizons to a unit impulse in a specific market today. For instance, the U.S. market responds to a unit impulse in the U.K. market by -0.096 on day two and 0.040 on day three (see the upper-left panel), and its response to a unit impulse in the Canadian market is 0.067 on day two and 0.037 on day three (see the lower-left panel).

Evidently, reactions to unit shocks in the U.K., Canadian and Japanese markets are insignificant (see the top left, the bottom left and the bottom right panels). In the first 10 days, there are not many apparent reactions to a unit shock in any of these three markets. As the time horizon extends from 10 to 21 days, there is no obvious increase or decrease in the intensity of reactions.

In contrast, responses of the U.K., Canadian and Japanese markets to a unit shock to the U.S. market on day two are all strong and positive. Among them, the Japanese market exhibits the strongest reaction as well as the greatest sum of adjustments over a one-month

Table 5.9: Impulse Responses to a Unit Shock in Each Market: 1985–1993*

Impulse responses to a unit shock in FT100					Impulse responses to a unit shock in S&P500			
k	U.K.	U.S.	CANADA	JAPAN	U.K.	U.S.	CANADA	JAPAN
1	1.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000
2	-0.057	-0.096	-0.048	0.019	0.372	0.119	0.209	0.441
3	0.020	0.040	0.021	-0.005	-0.083	-0.102	-0.048	0.037
4	0.007	-0.025	0.017	0.055	0.089	0.042	0.051	-0.036
5	0.049	0.043	0.030	0.026	-0.011	-0.135	-0.088	-0.010
6	0.021	0.023	0.001	0.009	0.052	0.121	0.085	0.041
7	0.040	-0.014	-0.016	0.019	0.026	-0.004	0.037	-0.035
8	-0.056	-0.048	-0.026	-0.062	0.042	0.022	0.030	0.016
9	-0.001	-0.055	-0.044	-0.064	0.019	-0.008	0.042	0.059
10	0.053	0.088	0.016	0.016	-0.039	-0.039	-0.051	0.005
11	0.132	0.000	0.048	0.093	-0.028	-0.001	-0.032	0.011
12	-0.032	-0.024	-0.002	0.024	0.073	-0.019	0.006	0.041
13	0.004	-0.029	-0.015	-0.108	0.007	-0.014	0.011	0.009
14	-0.001	0.002	-0.039	0.042	0.040	0.021	0.044	0.003
15	0.054	0.041	0.012	0.061	0.022	-0.006	0.017	0.008
16	-0.000	-0.001	0.015	0.037	0.017	0.008	0.020	-0.032
17	0.021	-0.033	-0.022	0.062	-0.016	-0.000	0.016	0.014
18	-0.029	0.000	-0.035	-0.001	0.015	0.028	0.027	0.035
19	0.060	0.080	0.033	0.013	-0.067	-0.070	-0.015	-0.007
20	0.023	-0.008	-0.007	0.028	-0.047	-0.054	-0.064	-0.062
21	0.038	0.030	0.013	0.001	-0.060	-0.001	-0.025	-0.099
Total	1.346	0.013	-0.049	0.364	0.425	0.907	0.271	0.439

Impulse responses to a unit shock in DAX30					Impulse responses to a unit shock in NIKKEI225			
k	U.K.	U.S.	CANADA	JAPAN	U.K.	U.S.	CANADA	JAPAN
1	0.000	0.000	1.000	0.000	0.000	0.000	0.000	1.000
2	-0.090	-0.067	0.018	-0.080	-0.069	-0.023	-0.039	-0.032
3	0.039	0.037	0.042	-0.065	-0.030	-0.017	-0.010	-0.072
4	-0.079	-0.064	-0.019	0.000	-0.013	0.005	-0.002	-0.027
5	0.042	0.114	0.134	0.057	0.014	0.016	0.016	0.045
6	-0.013	-0.110	-0.034	-0.002	-0.068	-0.034	-0.022	0.003
7	-0.100	0.020	-0.052	-0.071	-0.006	-0.025	-0.007	-0.030
8	0.101	0.005	0.040	0.011	-0.005	-0.008	-0.011	0.012
9	0.045	0.039	0.039	-0.016	-0.028	0.002	-0.005	0.003
10	-0.001	0.005	0.042	-0.058	-0.010	0.006	0.003	0.057
11	0.024	0.001	0.027	-0.052	0.010	-0.004	0.001	0.052
12	0.025	0.068	0.023	-0.043	0.011	0.018	0.015	-0.016
13	0.012	0.086	0.043	-0.017	0.019	0.036	0.037	-0.008
14	-0.128	-0.104	-0.069	-0.027	-0.000	0.013	0.018	-0.007
15	-0.044	0.005	-0.036	-0.096	-0.012	-0.014	-0.005	-0.037
16	0.055	0.021	-0.023	0.031	0.017	-0.006	-0.000	-0.023
17	0.014	0.044	0.037	0.016	-0.006	0.014	0.006	0.043
18	-0.062	-0.058	-0.021	-0.008	0.003	0.014	0.025	0.017
19	0.004	0.048	0.035	-0.014	-0.008	-0.016	-0.012	0.040
20	0.064	0.077	0.109	0.052	-0.002	-0.031	-0.011	-0.038
21	0.057	0.004	0.050	0.159	0.011	-0.009	-0.001	0.004
Total	-0.034	0.170	1.386	-0.223	-0.172	-0.061	-0.007	0.985

* The ij th entry in each panel represents the response of the j th market on a k -day horizon to a unit shock σ today in a specific market

period. Likewise, the reaction of the U.K. market to the U.S. unit impulse on day two is also substantial. The sum of its responses over a one-month period is a close second to that of Japan. However, the Canadian market reacts the least to a unit shock to the U.S. market, which is consistent with the result demonstrated in Table 5.6 and is attributable to the concurrent trade operation between the two markets.

4. Effects of Economic Innovations on World Equity Market, an Event Study

As a complement to the VECM approach, an event study is performed to investigate to what extent fundamental innovations are transmitted across world equity markets. Specifically, correlations among the major equity markets in response to some unanticipated economic events will be examined in a multivariate-regression system. The directions and magnitudes of the impacts produced by these events are indicated by coefficients of event dummies for announcement days.

4.1. Methodology

The multivariate-regression system estimated consists of four seemingly unrelated regressions and is formulated as:

$$\epsilon_t = \sum_{k=1}^{14} B_k D_{kt} + v_t \quad (5.14)$$

ϵ_t is a 4x1 vector of residuals obtained from equation (5.3). These residuals represent variances in equity returns of the four markets not explained by their autoregressive lags and

the error-correction terms. The purpose of the experiment to use these residuals as dependent variables in this event study instead of rates of changes usually used in previous event studies is to eliminate the autoregressive effects produced by previous market changes. In this way, estimated coefficients may reflect more accurately the effects of the economic events examined. k denotes the number of event-windows. Since the day-one and day-two impacts of seven economic events on these four markets are to be investigated, there will be fourteen event windows. B is a 4×14 matrix of event-window coefficients. Finally, D is a 14×1 vector of event dummy variables that are the same for all equations.

$$D_{k,t} = \begin{cases} 1 & \text{if event } k \text{ occurs} \\ 0 & \text{otherwise} \end{cases}$$

The day-one and day-two effects of each event window will be estimated separately. Thus, D_1 takes on the value one for the first trading day after the announcement of Event I and zero otherwise. D_2 takes on the value one for the next trading day of Event Window I and zero otherwise. D_3 to D_{14} are defined similarly for Event Windows II to VII respectively.

The link among the four markets lies in forecast errors v_t , which is a 4×1 vector of variances unexplained by all autoregressive lags of the four markets, the error-correction terms and the seven events. The characteristics of the forecast errors are described by the following set of conditions.

$$E(v_t) = 0, \quad E(v_t v_s') = \begin{cases} \omega_v I & \text{for } t=s, \\ 0 & \text{otherwise} \end{cases} \quad (5.15)$$

$$E(v_{it} v_{jt}') = \begin{cases} \omega_{ij} I & \text{for } i \neq j, \quad t=s \\ 0 & \text{otherwise} \end{cases} \quad (5.16)$$

Equation (5.15) imposes the classical condition that errors are serially uncorrelated within each equation. The second condition (5.16) allows for non-zero covariance between errors of different equations, meaning that errors are contemporaneously correlated across equations. The information concerning the correlation structure of forecast errors may be summarized by the system covariance matrix.

$$V = E(vv') = \Omega \otimes I.$$

4.2. Descriptions of events and hypotheses

The world equity market impacts of the following seven unrelated and unexpected economic events taking place in the United States, the United Kingdom and Japan will be examined in this section to evaluate the degree of comovements among world equity markets in response to innovations in economic fundamentals. The events examined are selected on three bases. First, they are all real economic shocks with direct or indirect effects on domestic interest rates. Second, they are unexpected. Third, each event selected must at least have significant effect on the domestic equity market.

A summary description of all events and the days of event windows is provided in Table 5.10. Statistical hypotheses for world market reactions to these events are relevant to the first trading day after the announcement because on many occasions market trends reverse the next trading day due to new information.

Table 10. List of Events

Date	Event Description
Event I	
3/17/89	Unexpected U.S. inflation. PPI rose by 1% in Feb, which was the second consecutive increase
3/17/89	The first trading day for UK, US and CAN after the U.S. Labor Dept. announced the news
3/20/89	The first trading day for JAP after the news was announced
Event II	
10/13/89	The U.S. stock market panic triggered by the failure of UAL takeover, the expected tight credit and disappointing third quarter earning reports.
10/13/89	The first trading day for US and CAN after the news of UAL was reported in the newspapers
10/16/89	The first trading day for UK and JAP after the news was reported in the newspapers
Event III	
10/2/90	The Dept. of Finance of Japan announced rescue measures to support its sagging stock market
10/2/90	The first trading day for all markets after the Minister of Finance announced the news
Event IV	
10/26/90	The Treasury of the United States announced an unexpected near record deficit due mainly to an 9.5% increase in spending and an equal decrease in corporate tax revenue
10/26/90	The first trading day for UK, US, and CAN after the U.S. Treasury announced the news
10/29/90	The first trading day for JAP after the news was announced
Event V	
11/14/91	The U.S. Senate passed an amendment on Nov. 13 to cap the interest rate charged on bank credit cards. The new legislation hurt the country's biggest banks.
11/15/91	The first trading day for US and CAN after the effects of the new law sank in
11/18/91	The first trading day for UK and JAP after the effects of the new law sank in
Event VI	
9/16/92	The U.K. government suspended its currency from joining the EMS after several attempts from the Bank of England to support the pound sterling failed. The pound was allowed to float
9/17/92	The first trading day for all markets after the news was announced.
Event VII	
1/26/93	The U.K. interest rate was reduced sharply to a 15-year low, which was possible due to its withdrawal from the EMS.
1/26/93	The first trading day for UK, US and CAN after the news was announced
1/27/93	The first trading day for JAP after the news was announced

Event I

The Labor Department of the United States announced on March 17, 1989 that the index of producer prices (PPI) for finished goods, mainly food and energy, rose 1 percent for the second consecutive month in February, which was an equivalent of a 12.7 percent annual rate. The January-February monthly surge of PPI registered the worst two-month increase in nearly eight years. Fundamentally, the surge in PPI was attributed to a large budget deficit and seven years of economic growth at full employment level and near full capacity. In the short-run, the greater-than-expected increase in PPI was driven by volatile food and energy prices.

The report of the price surge stunned the U.S. financial market that had expected a much lower increase in the index. The unexpected inflation increased the cost of production and the financial market expected a rise in the interest rate. During the first trading day after the report, which was the event day Friday, S&P500 went down by 2.3 percent on predictions that the Federal Reserve Banks would raise the interest rate to prevent inflation.

With the interest rate in the United States expected to rise, the U.S. dollar was expected to appreciate against other currencies. To prevent this from happening, foreign central banks would be forced to raise its own interest rate. Although a stronger U.S. dollar would stimulate foreign exports and import-substitution production if no actions were to be taken by foreign central banks, inflation due to a strong global growth and an uncertain currency market were the main concerns of the central banks at the time the event occurred. Therefore, world financial markets expected their own central banks to raise interest rates to keep up with the U.S. rate. For these reasons, the foreign equity prices should be expected

to fall as required by the asset market arbitrage condition (3.5). This predicted reaction to Event I may be summarized in the following hypothesis

$$H_1: \beta_{i,1} < 0 \text{ for all markets}$$

Event II

Since September 1989, the Bush administration had been trying to force the Federal Reserve Banks to ease credit so as to relieve the appreciating pressure on the dollar and to stimulate the economy. The Board of the Federal Reserve Banks had been resisting such moves and its Chairman, Alan Greenspan, had been reluctant to lower interest rates merely to keep the dollar within an agreed-on exchange range. In addition, the U.S. Senate had just failed to pass capital-gain tax cut legislation and third-quarter earning reports had been disappointing. All these had unnerved some market participants.

The situation was further exacerbated by the news on late October 13, 1989 that a respected management group announced that its attempt of a \$6.8 billion takeover of UAL Corp., the United Airline parent, had failed because it had not been able to obtain financing for the acquisition. Investors viewed the UAL problem as another indicator of tight credit. With slow economic growth and poor expected corporate earnings, banks were very cautious of lending in general and of lending for corporate takeovers in particular, to prevent loan loss. Problems in the UAL takeover sparked a panic sell-off first in UAL and other possible takeover targets and then the sell-off quickly spread to the broader market.

Later in the trading day, the U.S. Treasury Secretary Nicholas F. Brady urged calm in marketplace. Federal Reserve Board Chairman Alan Greenspan later reportedly indicated

that, to avoid a financial crisis, the Fed was prepared to provide liquidity by purchasing T-Bills from banks, giving them cash that could be loaned out. However, all these did not reverse the steep plummet on the event day. By the end of the trading day, the Dow Jones Industrial Average was down 190 points within an hour or so, which registered the steepest single day fall since the October 1987 market crash, and probably the fastest fall ever. S&P500 fell by more than 6 percent. The overvalued U.S. dollar also began to decline later in the day as investors tried to get rid of their financial investments in the United States.

Anticipating the Fed's move to prevent further panic selling and viewing the economic fundamentals as reasonably good, the market tension subdued on the following Monday, the next trading day ⁵⁴

The fundamental reason for this U.S. equity market fall was a mix of all the bad news the U.S. financial market feared: expected higher interest rates because of excessive demand for credit, a continuously strong dollar that hurt the economy's exports and the slow economic activities. The expected higher U.S. interest rate would lead to expected higher interest rates worldwide for the reasons discussed earlier. Moreover, at a time when inflation was not a serious problem, higher nominal interest rates indicated higher real interest rates, which would do more harm to the economy by increasing the cost of investment and thus hurting long-term growth. The expected slow down in the U.S. economy would hurt foreign economies as well, offsetting, or partly offsetting, the positive effect a strong dollar had on foreign exports. Thus, we should expect all four markets to fall together:

⁵⁴A good thing that resulted from this panic sell-off was that it forced the Fed to ease credit, which the Bush administration had been trying to do, unsuccessfully, for weeks

$H_2: \beta_3 < 0$ for all markets and $|\beta_{US}| > |\beta_{i,i}|$ where i = the U.K., Canada and Japan

Event III

The year 1990 marked the end of a very bullish Japanese equity market and the beginning of a persistent sagging market. Nikkei225 started at 38712.88 at the beginning of the year but closed at 20983.5 at the end of September, about 46 percent lower in value in just three quarters. The poor performance of the equity market was mainly because of 16 months tight credit, high interest rates to constrain inflation in Japan, and futures and options trading. Concern about the plummeting equity prices prompted Japan's Ministry of finance to come to the rescue of the market on October 1, 1990. Finance Minister Ryutaro Hashimoto announced several measures the government would take to support the equity market. Among them were fewer restrictions on investors who traded on credit, shorter trading hours for the equity futures and options market and some tax breaks to encourage equity market capitalization. On October 2, Mr. Hashimoto reassured the market that he wanted to see stock prices stabilized.

The Japanese financial market interpreted his strong statement of support as an indicator that the central bank would stop raising interest rates and perhaps ease credit. In the short-term money market, a decline in the overnight interest rate was not counteracted by the Bank of Japan, which strengthened investors' beliefs that the central bank would ease monetary policy. The aggressive government intervention and the central bank's action boosted the confidence of investors in the market's ability to recover and thus spurred strong recoveries in both bond and equity markets. Nikkei225 gained 2676.55 points on October 2,

up about 13 percent. This registered the biggest one-day gain ever in Japanese stock market history.

World equity markets were supposed to rise along with the Japanese market at the news. From a global economic point of view, lower Japanese interest rates would increase the profitability of capital investment and increase the Japanese economic growth. These would in turn feed growth in the rest of the world. Besides, from the beginning of 1990 to September, the Japanese Yen appreciated against major currencies, the U.S. dollar in particular, due to huge Japanese trade surplus and high Japanese interest rates. Although a weaker dollar would be helpful to U.S. exports, it hurts both the U.S. bond market and the equity market. It is similar for the United Kingdom and Canada. The expected lower Japanese interest rates would help currencies of other economies to gain some strength, which would in turn boost their equity markets. Therefore, the event should induce positive, though to a lesser degree, reactions from other major equity markets:

H₁. Thus $\beta_s > 0$ for all markets and $|\beta_{s,JAP}| > |\beta_{s,i}|$ where $i=U.K., U.S.$ and Canada.

Event IV

The U.S. Treasury reported on October 26, 1990 that the federal budget deficit of fiscal year 1990 was \$220.4 billion, just \$800 million shy of the record high \$221.2 billion in 1986. The new deficit figure was up by 44 percent from the previous year and was more than double the \$100.0 billion target for the current year. The budget deficit was blamed on a 9.4 percent increase in spending but only 4.1 percent rise in revenue. This lower than expected revenue was attributed to a 9.5 percent decline in corporate income-tax receipts that reflected

a downturn in corporate profit. The treasury also reported that the official White House projection of the budget deficit in the next fiscal year would be \$253.6 billion, which would set another record.

Although the Bush administration had twice revised its forecast of the deficit earlier in the year, the announced deficit figure still came as a shock. Investors predicted both higher interest rates, thus a higher cost of investment, and a possible tax increase. The forward-looking U.S. market reacted immediately, closing at 1.8 percent lower. The fall could have been steeper if it had not been for the optimism about the third-quarter figures on the economy to be released in the coming week.

The impact of this event on international equity markets is suggested by a similar case of asymmetric fiscal expansion in Section 2 of Chapter IV. The unexpectedly high U.S. budget deficit would raise both prices and interest rates in the United States, which in turn would raise the cost of capital and reduce corporate profits. Both results would lead to a lower demand for capital. Since capital investment adjusted only slowly, the U.S. equity market undershot its long-run level.

Lower demand for U.S. capital should generally have a negative effect on foreign economic activities and profit expectations. Interestingly, this event might provoke positive reactions from some countries contingent on two situations. First, if the confidence of world investors in U.S. government bonds was shaken due to the huge deficit, they would try to get rid of their U.S. bonds and invest their money elsewhere. When this happened, other major equity markets, such as the United Kingdom and Japan, would be expected to react positively. Second, if the U.S. central bank was to raise the interest rate high enough so that the U.S.

dollar would appreciate, it would boost the exports of other economies, which will also induce positive reactions from other markets⁵⁵

However, the Canadian equity market was expected to go down with the U S market. Fundamentally, expected higher U S interest rates and higher price levels due to the large fiscal deficit would slow down economic activity in the United States. As a close neighbor and trade partner, the Canadian economy would be directly affected. Moreover, most of the European and Japanese investors held Canadian bonds along with U.S. bonds in their "dollar" position. When international investors lost confidence in the currency of a highly indebted United States, they wanted to dump their dollar-denominated bonds, or to be exact, their U.S. dollar-denominated Canadian bonds more than U.S. bonds. This put downward pressure on the Canadian currency. To defend the currency, the Bank of Canada was forced to raise its interest rate and intervene in foreign exchange markets. This partly explains why the Canadian interest rate and the Canadian equity market are sensitive to the U.S. budgetary news that generally affect to the U S. interest rate and the U.S. exchange rate against all other major currencies.

Therefore, the following equity market adjustments should be expected in response to this event:

$$H_4: \beta_{7,US} < 0, \beta_{7,CAN} < 0, \beta_{7,UK} > 0 \text{ and } \beta_{7,JAP} > 0.$$

⁵⁵The data show that U S dollars experienced an appreciating spell from the last quarter of 1990 to early 1991.

Event V

On November 13, 1991, the U S Senate passed an amendment to a pending bank reform bill to set a limit of 14 percent on the annual interest charges for bank credit cards. The average rate was then 18.9 percent, with seven of the ten leading banks charging 19.8 percent. The amendment was passed immediately after it had been proposed on the belief that a lower credit card rate would help stimulate consumption and get consumer confidence moving again.

On November 14, the news came out and the U.S. equity market was crushed by the Senate's unexpected passage of this amendment. Implications of the Senate's move were twofold. First, some leading banks such as Citicorp and First Chicago earned more than 50 percent of their profits from credit-card operations, while others such as Chase Manhattan Corp. and Banc One earned 20 to 35 percent from credit-card operations. The legislated lower rate of charge on credit cards would hurt the profitability of the banking system indefinitely. Second, the amendment threw immediate uncertainty on the credit-card securities market.⁵⁶ Investors on the credit-card securities market feared that a limit on credit card rates would squeeze the profit margin on credit card operations and make it difficult for banks to meet interest payments on credit-card securities.

Repercussions of the amendment were widespread. However, not many securities traded hands on November 14 since sellers outnumbered buyers by a substantial margin and

⁵⁶Credit-card securities were one of the most popular products on Wall Street at the time. They were in the form of credit-card backed bonds created by pooling thousands of consumer credit-card accounts and putting them into a package structured as a fixed-income security. Investors in this kind of bonds were promised a fixed interest rate that was higher than the T-bill rate and was paid monthly or quarterly.

investors were reluctant to sell at a bargain price. On November 15, when investors were very anxious to get rid of their holdings, the Dow Jones Industrial Average plummeted by 120.31 points and the S&P 500 composite, by 15 points.

Responses of foreign markets would be expected to parallel that of the U.S. market. Hit by the new legislation, leading U.S. banks would be forced to tighten credit requirements on both consumer and commercial loans to reduce the risk of default. Consequently it would be hard to obtain loans for investment, which would hurt both the U.S. and foreign economic activities. Thus, the next hypothesis is:

$$H_5: \beta_9 < 0 \text{ for all markets}$$

Event VI

The British government suspended pound sterling participation in the European Monetary System (EMS) on September 16, 1992.⁵⁷ The decision was announced after the Bank of England had failed to halt the currency's fall below its floor against the German mark despite two sharp interest-rate increases during the day.

Britain's move came after a week of turmoil on European currency markets that had followed two months of efforts by European central banks to keep their exchange rates against the mark within EMS limits. The Bank of England reportedly spent £15 billion of its £44 billion foreign currency reserves on September 16 to support the pound. However, heavy

⁵⁷The EMS involves a joint currency float, in which member currencies are allowed to fluctuate within designated narrow ranges relative to other participating currencies. Thus, a participating country has a fixed exchange rate regime within the EMS and a flexible exchange rate regime against nonparticipating countries. The main goal of the EMS is to promote European monetary integration and to create an area of exchange rate stability among European Community countries.

intervention by the Bank of England and other European central banks on September 14-16 failed to slow the flight of capital to the mark.⁵⁸ Raising Britain's interest rate did not work either. The Bank of England increased its base interest rate twice on September 16, from 10 percent to 12 percent and then to 15 percent. Finally, the pound was allowed to float at 7:30 P.M. (after the London Stock Exchange closed). On September 17, the pound was stabilized at 5 percent below its previous floor value and the exchange rate returned to 10 percent. On the same day, FT100 went up by about 4.5 percent.

This currency market crisis was mainly blamed to the inflexible monetary policy adopted by Germany's central bank to prevent inflation and the continued stagnant economy in many European countries. After the announcement of the currency suspension, the pound was able to float freely and the British central bank was able to lower interest rates to stimulate the U.K. economy. The London stock market surged on the news. FT100 gained 105.6 points, up about 4.4 percent.

Financial markets of non-EMS member countries were expected to react positively, though probably not immediately, to this event. This European currency crisis had its roots in the German unification. The high cost of the unification, such as huge budget deficit because of the need to inject money into the former communist eastern region and the inflationary effects of the deficit, had kept German interest rates high. Higher German interest rates had raised the value of the mark against other major currencies as international capital was attracted to German bond markets. Many industrial countries had urged the Bundesbank

⁵⁸The Sweden's central bank increased its base interest rate drastically on September 16 to defend its currency. Spain devalued its currency on September 17, though the currency still remained in the EMS.

to reduce its interest rate in order to relieve the downward pressure on other currencies and stimulate economic activities worldwide. The Bundesbank had decided to cut two key interest rates on September 14. However, international financial markets hoped that the crisis would put further pressure on the Bundesbank to further reduce interest rates. Thus:

$$H_6: \beta_{1i} > 0 \text{ for all markets and } |\beta_{11,UK}| > |\beta_{11,i}| \text{ where } i = \text{the U.S., Canada and Japan.}$$

Event VII

The Bank of England announced on January 26, 1993 a 1 percent reduction in its base lending rate from 7 percent to 6 percent. Coming at a time when the economy was experiencing persistent stagnant economic activities and low inflation, the reduction brought the real interest rate to its lowest level since 1977. After this reduction, British interest rates were 4 percent lower than that prevailing before Britain withdrew from the European Community's exchange rate mechanism. The withdrawal had helped the interest rate cut, which was very much needed by the ailing British economy. The pound depreciated relatively to both the mark and the dollar at the interest rate cut.

The full percentage point fall in the interest rate surprised the British financial market where investors had expected a much smaller reduction. The London stock market reacted positively to the news. FT100 rose by 2.3 percent to close at 63.8 points higher.

Other major equity markets, on the expectation of a lower cost of real investment, more active British economy and more exports to Britain, should move along with the London market. Therefore,

$$H_7: \beta_{1j} > 0 \text{ for all markets.}$$

A crucial task in an event study is to decide timings for event windows (see Table 5.10 for a summary). Due to non-synchronized trading time, this is not always easy. If an event occurs in Japan, such as Event III, then the first trading day after the announcement, which is also the announcement day, is the same for all four markets.

For Event VI or VII that took place in Britain, event day one is the announcement day for the London and the North American markets. The decision then focuses on the Japanese market. For Event VI, the announcement was made after the London market had closed and before the Tokyo market first opened the next day. Thus, event day one is the same for all markets. In the case of Event VII, event day one for Japan is the next trading day after the event announcement.

Event day one of each of the four U.S. events is the announcement day for the North American markets. Operating before the North American markets, Japan can only react to the four events on the next trading days after announcement days. Since Britain has a sixty-minute overlapping trading operation with the North American markets, it is crucial to know the exact timing of event announcements to decide event day one for the U.K. market.

Among the four U.S. events, Event I and VI were announced in morning newspapers, the U.K. market could observe their impacts on the U.S. market and had time to react accordingly. Therefore, event day one's for the U.K. market on these two occasions are the announcement days. In the cases of Event II and V, event day one's for the U.K. market are the second trading day after event announcements.

To ensure that estimates of the model reflect precisely the impacts of the selected events, market movements due to other factors arising around event days are studied. Any

other news prior to, or concurrent with the selected events that may have important influence on market movements will be mentioned in the next section for the benefit of the reader

4.3. Estimates of the SUR and the test results

Estimates of equation (5.14) are reported in Table 5.11. The predicted signs of these impacts are based on the hypotheses for the respective day-one event windows. Event dummy coefficients and t-statistics are reported for each market equation in the SUR system. These coefficients are significantly different from zero at 1 percent, 2 percent, 5 percent, 10 percent or 20 percent confidence levels respectively if their respective t-statistics are 2.576, 2.326, 1.96, 1.645 or 1.282 in absolute values.

As shown in the table, the impacts of the four U.S. events on the major world markets are mixed. The estimated event dummy coefficients of Event I are statistically significant for the U.K., U.S. and Canadian markets at 1 percent, 2 percent and 5 percent confidence levels respectively. The comovement among these markets confirms the prediction that the expected increase in the U.S. interest rate would affect world equity markets similarly. As an exception, there is little evidence of significant reaction from Japan to the news, even though the direction of the reaction is as predicted.

The estimated day-one impacts of Event II on both the U.S. and Canadian markets are very significant. The two markets are also found to rebound on the next trading day. However, such drastic change in the North American markets appears to have only a moderate effect on the U.K. market and no effect on the Japanese market at all.

The estimated effects of Event IV on the four markets are mixed. While the day-one

event dummy coefficient for the U.K. market barely differs from zero, that for the Japanese market is very significant. Although the event dummy coefficients for the U.S. and Canadian markets are only mildly significant, they are in the predicted direction

The Event V dummy coefficients are significantly different from zero at 1 percent and about 7 percent confidence levels for the U.S. market and the Canadian market respectively. Again the event does not seem to affect the U.K. and Japanese markets significantly, though the estimated direction of the effect is as predicted

Apparently, the selected innovations occurred in either Japan or Britain did not exerted much influence on the major markets. The Japanese equity market scored a record by gaining about 13 percent in one day on October 2, 1990. However, other markets seem unperturbed. None of the estimated coefficients of Event III are statistically significant

Similarly, neither Event VI nor VII had any significant impact on any market other than the U.K. market. However, the Dow Jones Industrial Average and S&P500 had gained about 72.52 points and 5.69 points (about 1.4 percent) respectively the day before the event announcement at the news that the German central bank would lower two key interest rates. Under the circumstances, there may not be room for a further increase in the U.S. market

Although twenty-two out of the twenty-eight coefficients for day-one event windows have right signs, only nine of them are statistically significant at a 5 percent confidence level. This seems to suggest that economic innovations in none of the three countries can produce worldwide impact. Since the estimated results from the VECMs in Section 3 demonstrate a great deal of interactions among the four markets, the estimated event effects reported in the table seem counter-intuitive.

Table 5.11: The Estimated Impacts of Seven Events on Equity Markets, Equation (S.14):

	EVENT I	EVENT II	EVENT III	EVENT IV	EVENT V	EVENT VI	EVENT VII	R2	DW
Expected signs*	(-)	(-)	(+)	(+,-)	(-)	(+)	(+)		
Coefficients	-0.021 -0.007	-0.012 -0.022	0.007 0.019	-0.001 0.003	-0.008 -0.014	0.031 0.026	0.018 0.002	0.046 2.046	
t-statistics**	-2.559 -0.872	-1.373 -2.751	0.825 2.256	-0.116 0.388	-0.943 -1.744	3.731 3.016	2.221 0.276		
Coefficients	-0.023 -0.013	-0.060 0.028	-0.005 -0.011	-0.016 -0.009	-0.035 0.008	0.004 0.007	-0.003 -0.003	0.070 2.040	
t-statistics	-2.581 -1.453	-7.284 3.184	-0.599 -1.216	-1.846 -1.052	-4.292 0.872	0.511 0.778	-0.311 -0.356		
Coefficients	-0.012 -0.007	0.034 0.026	0.000 -0.000	-0.008 0.000	-0.010 0.010	-0.003 -0.001	0.001 0.001	0.059 2.023	
t-statistics	-2.154 -1.352	-6.600 4.822	0.052 -0.083	-1.571 0.025	-1.882 1.773	-0.592 -0.178	0.278 0.160		
Coefficients	-0.003 -0.003	0.007 0.012	0.110 0.001	0.022 -0.003	-0.014 -0.001	-0.005 -0.006	0.001 0.036	0.059 1.960	
t-statistics	-0.208 -0.217	0.546 0.891	8.132 0.093	1.595 -0.232	-1.016 -0.050	-0.438 -0.438	0.090 2.795		
chi-squares***	6.830	21.015	19.917	5.878	9.712	2.428	0.688		
P-values	0.009	0.000	0.000	0.016	0.000	0.119	0.407		

* The expected signs are for the day-one impacts of the seven events on the four equity markets.

** The lower tail critical values for t-statistics at the 1%, 2%, 5%, 10% and 20% confidence levels are -2.576, -2.326, -1.96, -1.645 and -1.282 respectively.

***The critical value for chi-square at a 5% level is 3.84.

However, there may be an explanation for the ineffectiveness of the U.S. fundamental changes on world equity markets. Recall that the dependent variables of this event study formulated in equation (5.14) are the residuals obtained from the estimated VECM (5.4). Due to non-synchronized trading hours, the Japanese market always responds, if it does at all, to events occurred in the United States on the second trading day. So does the U.K. market in the cases of Events II and V.

By construction, the VECM model (5.4) includes the one-period lagged U.S. returns as an independent variable for all four markets. The U.K. and Japanese markets, which are efficient by assumption, respond to the first-order lagged U.S. returns that contain useful information about the event impacts on the U.S. equity market. Consequently, regressions for these two markets have already included the impacts produced by the selected U.S. events. It follows that using the residuals from regression system (5.4) as dependent variables in the event study may not yield accurate estimations for the U.K. and Japanese markets.

To verify this thought, model (5.14) is re-estimated using rates of changes in equity prices as dependent variables:

$$R_t = \sum_{k=1}^{14} B_k D_{kt} + v_t. \quad (5.17)$$

Comparing the estimates of equation (5.17) summarized in Table 5.12 to those reported in Table 5.11, it is apparent that estimated event dummy coefficients of Events I, II, IV and V for the U.S. and Canadian regressions obtained from the two SURs are similar. It is also noticeable that the impact of the U.S. budgetary news (Event IV) on the Canadian

market is significantly different from zero at a 1 percent level. The significance of the impact, as discussed previously, is due to the vulnerability of Canadian interest rates to fluctuations in U.S. interest rates and the exchange rate between Canadian and U.S. dollars.

As expected, the estimated event impacts using (5.17) provide strong evidence for the comovement between the U.K. market and the North American markets in response to all four U.S. events. The estimated event dummy coefficients for Events II and V are significantly different from zero at 1 percent and 5 percent confidence levels respectively.

The estimated impacts of Events I, II and IV on Japanese returns are also stronger than the results reported in Table (5.11). Among them, the estimated impact of Event II on the Japanese market is qualitatively different from the one obtained from (5.14). The Japanese return now moves in the predicted direction in response to this event. It is also worth mentioning that the statistical significance of the Event IV dummy should be discounted to some extent since the Japanese market had been declining over a week prior to the event due to a less-than-expected cut in the discount rate by Japan's central bank. The news from the U.S. market only made the situation worse.

Although twenty-three out of twenty-eight event day-one coefficients have the predicted signs, only Event V among all seven events is found to produce a significant comovement among all four markets. The hypothesis that the event should affect all four markets similarly cannot be rejected at a 5 percent confidence level in this case. However, if Japan is excluded, the rest of the markets are found to be similarly affected by three out of the four U.S. events, which suggests that the U.K. and Canadian markets have been more responsive to innovations in the U.S. fundamentals.

Table 5.12: The Estimated Impacts of Seven Events on Equity Returns, Equation (5.17):

	EVENT I		EVENT II		EVENT III		EVENT IV		EVENT V		EVENT VI		EVENT VII		R2	DW
	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)		
Expected signs*																
Coefficients	-0.018	-0.009	-0.032	-0.010	0.014	0.014	-0.010	-0.000	-0.017	-0.010	0.042	0.033	0.021	-0.001	0.057	2.037
t-statistics**	-2.121	-1.042	-3.536	-1.200	1.494	1.516	-1.133	-0.053	-1.909	-1.155	4.799	3.629	2.358	-0.125		
Coefficients	-0.023	-0.010	-0.063	0.027	0.001	-0.012	-0.016	-0.009	-0.035	0.007	-0.001	0.007	-0.001	-0.004	0.074	1.941
t-statistics	-2.589	-1.078	-7.575	3.084	0.097	-1.379	-1.890	-1.058	-4.256	0.774	-0.099	0.807	-0.149	-0.475		
Coefficients	-0.010	-0.010	-0.036	0.015	0.005	-0.004	-0.013	-0.001	-0.010	0.004	-0.003	-0.000	0.004	-0.000	0.054	1.508
t-statistics	-1.886	-1.915	-7.032	2.652	0.903	-0.682	-2.401	-0.187	-1.984	0.789	-0.565	-0.058	0.784	-0.065		
Coefficients	-0.012	-0.000	-0.019	0.018	0.124	-0.002	0.013	0.002	-0.029	0.003	0.010	0.003	0.001	0.036	0.068	1.903
t-statistics	-0.804	-0.009	-1.301	1.317	8.691	-0.150	0.899	0.166	-2.058	0.179	0.666	0.194	0.072	2.625		
chi-squares***	7.492		43.802		29.862		2.784		16.641		3.746		1.145			
P-values	0.006		0.000		0.000		0.095		0.000		0.054		0.285			

* The expected signs are for the day-one impacts of the seven events on the four equity markets

** The lower tail critical values for t-statistics at the 1%, 2%, 5%, 10% and 20% confidence levels are -2.576, -1.96, -1.645 and -1.282 respectively

*** The critical value for chi-square at a 5% level is 3.84

A weaker hypothesis is that the corresponding coefficients for the same event day-one dummy variable in the four regressions are jointly significant, meaning that the event examined had a significant effect on the four markets as a whole on their first trading day after the event announcement. The test statistics for the joint hypothesis, chi-squares and P-values, are presented in both tables. An estimated chi-square larger than the critical value of 3.84 indicates that the joint hypothesis should be accepted at a 5% level. The estimated P-values indicate the chances of making a mistake at accepting the joint hypotheses based on the current sample.

The estimates of equation (5.14) show that the joint hypothesis cannot be rejected for five out of seven events, and those of equation (5.17) show that the joint hypothesis cannot be rejected for four out of seven events. This result suggests that, in each of these cases, the overall effect of the event on the four markets as a whole was significant, even though the event may not influence each individual market.

It should be noted, however, that the joint significance of the effect of Event III is because of the strong reaction from the Japanese market only. None of the estimated coefficients for other markets are significant. Furthermore, a closer observation of the estimates show that the selected fundamental changes in Britain and Japan do not seem to affect markets other than their own. However, this result may not provide a general inference as to whether their economic innovations have any influence on other markets because only one event occurred in Japan and two occurred in Britain are examined.

5. Concluding Remarks

In this chapter, the characteristics of the integration of international equity markets in the long run and short run are investigated empirically using two approaches: the error-correction representation of a cointegrated vector autoregression system and an event study. While differing in some respects, the main results produced by the two procedures suggest the following similar stylized facts:

First, differences among the *ex post* rates of returns in the four equity markets exist on a daily basis, which is suggested by two facts. One is that all estimated contemporaneous correlation coefficients among returns on the four equity markets are less than perfect, though most of them are significant. The other is that all equity price indexes, with the exception S&P500, are tested nonstationary using daily data.

Second, evidence of cointegration is found for some markets during 1985-93, which suggests that equity prices in these markets have moved in parallel over the long run. This result provides, to some degree, supporting evidence for the theoretical prediction that there exists a long-run equilibrium equity price differential between the major economies based on underlying fundamentals.

Third, all equity markets have moderate to significant proportions of their variances produced collectively by innovations in foreign markets at the two-day to one-month horizons. If such innovations reflect fundamental disturbances in individual economies, this result implies that fundamental disturbances in an economy usually produce lagged and persistent impacts on equity markets, as suggested by the theoretical model.

Fourth, the U.S. equity market stands out as the most influential market in the world.

This leading role of the U S market is particularly evident in the event study. Joint hypothesis tests show that innovations in U S fundamentals that affected the U S equity market have generally induced worldwide equity market reactions.

Fifth, most estimated coefficients for the error-correction terms are insignificant, which provides supporting evidence to the prediction of the theoretical model that markets adjust only gradually to the previous disequilibrium.

Sixth, in most cases, the markets investigated have reacted to fundamental changes in the predicted directions. Nonetheless, not all of the estimated responses are significant, which indicates that national economic innovations have not always affected the world major equity markets with similar magnitude, at least not in the short run.

CHAPTER VI

CONCLUSIONS

1. Summary and Conclusions

Global consequences of national economic innovations are commonly analyzed in conventional open economy macroeconomic models. Although the asset market is an integral part of such models, the equity market is not generally considered. In the few attempts made by economists to incorporate the equity market into conventional macroeconomic models, they either do not discuss the determination of equity returns, or discuss the subject but do so within a small country model. The existing open economy macroeconomic models, therefore, do not provide an adequate framework in which the effects of national economic innovations on international equity markets can be examined explicitly.

The current dissertation develops a two-country macroeconomic model with optimizing agents, capital investment, traded and nontraded goods, flexible real exchange rates and uncovered real interest parity. The main objectives are to investigate theoretically the integration of international equity markets and to formalize conditions and mechanisms that govern this integration, which is defined as the equalization among expected returns on equities traded in different markets but with identical risk characteristics.

In this two-country world, the price of equity claims is determined by the marginal value of capital and the domestic equity market equilibrium, as defined in the asset market arbitrage condition. Innovations in real economic variables, such as government spending, the tax rate and the real interest rate, affect the expected return on capital, which in turn induce dynamic adjustments of the equity price, the capital stock and the real exchange rate of each economy.

The dynamics of the two individual economies are then synthesized and decoupled

into the world average and relative fundamentals. This distinction makes it easier to examine repercussion effects across equity markets produced by fundamental innovations.

As demonstrated explicitly by the model, expected equity returns (which equal actual returns under the assumption of perfect foresight) across economies are not generally equalized in the short run. With zero transaction costs, short-run deviations of the world equity price differential from its equilibrium, or equivalently, discrepancies between equity returns on different markets, may arise due to either negative correlations or nonsimultaneous movements between equity markets in response to innovations.

Negative correlations reflect the fact that innovations in one economy may change the fundamentals of different economies in opposite directions in the short run. Nonsimultaneous movements occur when the impacts of innovations in one economy are less effective on the other economy, or can only be transmitted to the other economy over time. Although the disequilibrium thus produced may not persist over the long run, it still creates abnormal profit opportunities that attract investors worldwide to increase their equity holdings on the contemporaneously and positively affected economy.

Nevertheless, changes in relative fundamentals created by innovations, and the resulted disequilibrium in the world equity price differential, will be eliminated gradually by repercussions effects associated with the innovations and international portfolio adjustments. Consequently, equity prices in the two countries, though sometimes drifting apart from each other, will always return to the equilibrium relationship based on underlying economic structures. This leads to the conclusion that the integration of international equity markets is a reasonable approximation of reality over the long run.

Besides the long-run and short-run characteristics of the international equity market integration, the model also demonstrates that macroeconomic news generally induces overreaction in equity markets. The overreaction is essentially attributable to the fact that the capital stock cannot adjust instantaneously. Consequently, the equity market has to adjust more than required in the long run to maintain equity market equilibrium in the short run. This may explain, to some extent, the volatility of world equity markets.

Characteristics of correlations among the U.S., U.K. Canadian and Japanese markets are then investigated and assessed empirically through two different approaches: the error-correction representation of a cointegrated vector autoregression system and an event study.

Except the U.S. equity price index, the U.K. Canadian and Japanese equity price indexes are found to be nonstationary, implying that rates of returns on these markets have drifted apart from each other when measured on a daily basis. In addition, contemporaneous correlations among rates of returns have been generally less than perfect, which provides further evidence that the four markets have not experienced comovements in the short run.

Evidence is also found for the theoretical prediction about the long-run equilibrium equity price differentials between economies. Cointegration tests indicate that, over the nine-year period examined, the U.S. equity price has moved in parallel with the Japanese and Canadian equity price indexes when measured in U.S. dollars, and with each of the other equity price indexes when measured in local currencies. This suggests that the discrepancies in equity returns between the cointegrating markets have been zero on average over the long run. However, data for even longer time period may provide stronger supporting evidence for the theoretical prediction of cointegration.

Estimates of the error-correction model suggest considerable interactions among the four markets and persistent effects of variations of one market on another. Innovations in foreign markets collectively account for, depending on different orderings of regressions, 16 to 33 percent of the U.K. market variances, 5 to 18 percent of the U.S. market variances, 54 to 56 percent of the Canadian market variance, and 12 to 17 percent of the Japanese market variances at the 21-day horizon. If such innovations reflect fundamental disturbances in individual economies, this result implies that fundamental disturbances in an economy usually produce persistent impacts on equity markets, as demonstrated by the theoretical model.

Besides, the U.S. equity market is found to be the most influential market in the world because its variations generally explain a greater portion of the forecast error of another market than other foreign markets can do together.

Although equity returns in the four markets are found more than often to react in predicted directions to the previous deviations of price differentials from their respective cointegrating relationships, only about one quarter of the coefficients are significant, which suggests partial error correction. This result is consistent with the dynamics of the world difference system discussed in the theoretical model. The theoretical analysis demonstrates that an innovation in fundamental determinants of equity returns generally produces an overreaction of the equity price differential from its long-run equilibrium. The adjustment of the equity price differential after this overreaction is a gradual process that follows a gradual change in the capital stock.

The event study shows that most estimated event dummy coefficients have the predicted signs, though some of them are insignificant. Joint hypothesis tests indicate that

innovations in U S fundamentals generally induce significant worldwide market adjustments in the predicted directions.

2. Potential Extensions

Incorporating microeconomic foundations into a conventional two-country framework, this model has the following advantages over the existing macroeconomic models (1) different sectors of the economy are modeled consistently; (2) the optimizing determination of equity returns in each economy can be analyzed explicitly, which may avoid *ad hoc* assumptions imposed on equity markets; (3) the optimizing determinations of world equity returns can be analyzed jointly with the help of a technique that decomposes the corresponding fundamental variables into world averages and differences; (4) the conventional discrete-time model is replaced by a continuous-time model so that intertemporal adjustments of the model dynamics in response to macroeconomic innovations may be reflected. Due to these special features, results yielded from this model can better reflect the true behavior of interdependent world equity markets.

Nevertheless, like many existing macroeconomic models, this model is also subject to limitations. In the real world, expected returns on equity claims may be affected by various economic activities, such as employment, residential investment, trade, direct international real investment, productivity, technological advancement, the discovery of new resources and more. In addition, nominal variables, such as the supply of money, expected inflation, the nominal interest rate, the nominal wage, etc. are also found to be among the most influential determinants of equity market returns. A model that does not include all these factors cannot

exhaust all the explanations to the stylized facts of international equity market dynamics

The current theoretical framework may be extended into several directions to broaden its applicability in the study of international financial markets. One extension is to endogenize the supply of labor. Then let capital and labor replace traded and nontraded goods as inputs of production, the wage rental ratio replace the relative price of nontraded goods in terms of traded goods, and the real exchange rate in terms of relative wages replace the real exchange rate in terms of relative prices of goods. Thus, the model will provide a framework in which the effects of the relative wage, the relative productivity and unemployment on world equity markets can be investigated.

Another useful extension to the model is to add a monetary sector to endogenize nominal interest rates and the nominal exchange rate so that the effect of the monetary policy may be investigated explicitly. The addition will surely increase the applicability of the theoretical model in the study of international equity market integration.

Empirically, a question remains how long is the long run. Cointegration tests and empirical examinations conducted in this research extends a period of nine years. Previous empirical studies suggest that the world major equity markets are cointegrated over an infinitely long time period. But are these markets cointegrated in a shorter period of time, such as five years? To find out the shortest possible period over which the world equity markets are systematically cointegrated will provide insight into a deeper understanding about international equity market integration.

Besides, as mentioned earlier, the ARCH effects and nonnormal distributions of equity returns are not considered in the current empirical research, which raises two questions (1)

If these effects are considered in the empirical investigation of dynamic interactions among the four equity markets, will the results be qualitatively different from those obtained from the current research? (2) How much will such empirical study improve forecasts of variations in these four equity markets? These questions could be addressed using a GARCH model in a multivariate setting

Appendix A: Steady State

Steady-state values of real equity prices, capital stocks and the real exchange rate can be obtained from (3.25) and (3.26) at $\dot{q} = \dot{q}^* = \dot{K} = \dot{K}^* = \dot{E} = 0$

$$\dot{q} = 0 = \alpha_1 \bar{q} + \alpha_2 \bar{K} - \alpha_3 \bar{E} + \alpha_4 G_N + \alpha_5 \tau + \alpha_6 r, \quad (\text{A.1})$$

$$\dot{q}^* = 0 = \alpha_1^* \bar{q}^* + \alpha_2^* \bar{K}^* + \alpha_3^* \bar{E} + \alpha_4^* G_N^* + \alpha_5^* \tau^* + \alpha_6^* r^*, \quad (\text{A.2})$$

$$\dot{K} = 0 = \beta_1 \bar{q} - \beta_2 \bar{K} + \beta_3 \bar{E} - \beta_4 G_N, \quad (\text{A.3})$$

$$\dot{K}^* = 0 = \beta_1^* \bar{q}^* - \beta_2^* \bar{K}^* - \beta_3^* \bar{E} - \beta_4^* G_N^*. \quad (\text{A.4})$$

Solutions for steady-state equity prices and the real exchange rate can be obtained by equating (A.1) and (A.2) and then solving for $\bar{q}$, $\bar{q}^*$ and $\bar{E}$:

$$\bar{q} = \omega_1 - \frac{\alpha_4}{2\alpha_1}(G_N + G_N^*) - \frac{\alpha_5}{2\alpha_1}(\tau + \tau^*) - \frac{\alpha_6}{2\alpha_1}(r + r^*), \quad (\text{A.5})$$

$$\bar{q}^* = \omega_1 - \frac{\alpha_4}{2\alpha_1}(G_N + G_N^*) - \frac{\alpha_5}{2\alpha_1}(\tau + \tau^*) - \frac{\alpha_6}{2\alpha_1}(r + r^*), \quad (\text{A.6})$$

$$\bar{E} = \omega_2 - \frac{\alpha_4}{2\alpha_3 - \alpha_6}(G_N - G_N^*) - \frac{\alpha_5}{2\alpha_3 - \alpha_6}(\tau - \tau^*), \quad (\text{A.7})$$

where $r = \xi = \xi^* = r^*$ and ω 's capture all endogenous variables

Equations (A.5) and (A.6) indicate that the steady state equity price of an economy will be affected by variables of both economies. For instance, an increase in government expenditures on nontraded goods at home will raise the domestic relative price of nontraded goods, therefore the cost of investment. At lower expected returns on capital, both the market value of capital, q , and investment will decrease, which will in turn reduce the domestic demand for foreign produced traded goods. Since the traded good sector is capital intensive, this also implies a lower demand for foreign capital, therefore less rental revenue for the foreign capital-supplying industry. As a result, $\bar{q}^*$ will fall too.

Equation (A.7) implies that a greater differential between the corresponding variables of the two economies produces a greater difference between P and P^* , which leads to a real appreciation.

Steady-state capital stocks $\bar{K}$ and $\bar{K}^*$ are obtained by substituting (A.5) and (A.6) into (A.3) and (A.4) to replace $\bar{q}$ and E :

$$\bar{K} = \omega_3 - \alpha_4 \left[(\Gamma + \Phi) - \frac{\beta_4}{\beta_2} \right] G_N - \alpha_4 (\Gamma - \Phi) G_N^* - \alpha_5 (\Gamma + \Phi) \tau - \alpha_5 (\Gamma - \Phi) \tau^* - \frac{\beta_1 \alpha_6}{\beta_2 \alpha_1} r, \quad (\text{A.8})$$

$$\bar{K}^* = \omega_4 - \alpha_4 \left[(\Gamma + \Phi) - \frac{\beta_4}{\beta_2} \right] G_N^* - \alpha_4 (\Gamma - \Phi) G_N - \alpha_5 (\Gamma + \Phi) \tau^* - \alpha_5 (\Gamma - \Phi) \tau - \frac{\beta_1 \alpha_6}{\beta_2 \alpha_1} r^*, \quad (\text{A.9})$$

where $\Gamma = \beta_1/2\alpha_1\beta_2$ and $\Phi = \beta_3/\beta_2(2\alpha_3 - \alpha_6)$.

The parameter Γ reflects the effects of innovations on the capital stock through the equity market. If an innovation leads to a higher demand for nontraded goods, thus raising the relative price of nontraded goods, market participants will expect a lower future income

of the capital industry. This will discourage investment, which implies that the capital stock will fall.

The parameter Φ captures effects of innovations through the real exchange rate. If an innovation increases the differential of the relative prices of nontraded goods, the real exchange rate appreciates. The appreciation will harm the domestic traded goods sector, thereby reducing the demand for domestic capital. Meanwhile, it will stimulate the foreign traded goods sector and affect the foreign capital stock positively.

An innovation that occurs in an economy, therefore, affects the capital stock through both the equity market effect and the exchange rate effect. The two effects work in the same direction at home and in opposite directions abroad.

Appendix B

In this appendix, solution paths for the difference subsystem discussed in the text are explicitly calculated using Laplace transforms ⁵⁹

If a function $F(t)$, defined for $t \geq 0$, is multiplied by e^{-st} and integrated with respect to t from zero to infinity, a transformed function $f(s)$ is obtained:

$$L[F(t)] = f(s) = \int_0^{\infty} \exp(-st) F(t) dt, \quad (B1)$$

where $L[F(t)]$ denotes Laplace transforms of function $F(t)$. The transform exists if (B1) converges for some value of s .

Three properties of Laplace transforms will be used in the following calculation.

Theorem 1. If $F(t)$ is continuous and its derivative $\dot{F}(t)$ is continuous or sectionally continuous (for instance, the value of a function takes jump movements) over every closed finite interval $0 \leq t \leq T$, and if $F(t)$ is of exponential order α as $t \rightarrow \infty$, then its Laplace transform exists for all $s > \alpha$. Moreover,

$$L[\dot{F}(t)] = sL[F(t)] - F(0),$$

where $F(0)$ is the initial value of function $F(t)$. Theorem 1 shows that the initial values of the world difference subsystem (3.50) of the model can be solved using Laplace transforms. The

⁵⁹ Applications of Laplace transforms in economic research can be found in Obstfeld and Rogoff (1984), Aoki (1986), Ambler (1988, 1989). Other references for the technique include Churchill (1958), and Spiegel (1992). The example shown in this appendix follows Spiegel (1992) and Ambler (1989).

distributional effects of an economic innovation on the two economies may then be estimated with the knowledge of initial values for (3.50)

Theorem 2. If a Laplace transform $L[F(t)] = f(s)$ exists, then given $f(s)$, the inverse transform denoted by $L^{-1}f(s)$ exists. Thus, a function $F(t)$ can be found such that

$$F(t) = L^{-1} f(s).$$

Theorem 3. If c_1 and c_2 are any constants of $F_1(t)$ and $F_2(t)$ that have Laplace transforms $f_1(s)$ and $f_2(s)$ respectively, then

$$L(c_1 F_1(t) + c_2 F_2(t)) = c_1 f_1(s) + c_2 f_2(s),$$

$$L^{-1}(c_1 f_1(s) + c_2 f_2(s)) = c_1 F_1(t) + c_2 F_2(t).$$

Therefore, Laplace transform is a linear operator

In what follows, Laplace transform is used to solve for the initial values of the difference system (3.50) after an anticipated policy innovation. Let c_{ij} and d_{ij} denote the elements of coefficient matrices C and D in (3.50) respectively. For simplicity, LF will be used instead of $L[F(t)]$ and superscripts d will be dropped from all variables. Taking the Laplace transform of the difference system (3.50) gives

$$\begin{bmatrix} s-c_{11} & -c_{12} & -c_{13} \\ -c_{21} & s-c_{22} & -c_{23} \\ -c_{31} & -c_{32} & s-c_{33} \end{bmatrix} \begin{bmatrix} L\Delta q \\ L\Delta K \\ L\Delta E \end{bmatrix} = \begin{bmatrix} \Delta \bar{q} + d_{11}L\Delta G_N + d_{12}L\Delta \tau \\ \Delta \bar{K} + d_{21}L\Delta G_N + d_{22}L\Delta \tau \\ \Delta \bar{E} + d_{31}L\Delta G_N + d_{32}L\Delta \tau \end{bmatrix}, \quad (B5)$$

where s is the transform variable, $\Delta \bar{q} = \bar{q}_t - \bar{q}_0$ and $\Delta \bar{E} = \bar{E}_t - \bar{E}_0$. Since the purpose of this exercise is to find initial changes in jump variables from their original steady-state values, ΔK will be ignored because the capital stock is predetermined and does not change in the short run after the innovation

Effects of an expansionary fiscal policy on the equity market can be estimated by solving the simultaneous equations (B5) with the help of the partial fraction (Theorem 3):

$$\begin{aligned}
 L\Delta q = & \frac{1}{\Omega_2}([(p_2 - c_{22})p_2 - c_{32}f_{23}](\Delta \bar{q} + d_{11}L\Delta G_N) \\
 & + [c_{13}f_{32} + c_{12}p_2]d_{21}L\Delta G_N + [c_{12}f_{23} + c_{13}(p_2 - c_{22})](\Delta \bar{E} + d_{31}L\Delta G_N)) \\
 & + \frac{1}{\Omega_3}([(p_3 - c_{22})p_3 - c_{32}f_{23}](\Delta \bar{q} + d_{11}L\Delta G_N) \\
 & + [c_{13}f_{32} + c_{12}p_3]d_{21}L\Delta G_N + [c_{12}f_{23} + c_{13}(p_3 - c_{22})](\Delta \bar{E} + d_{31}L\Delta G_N)) \\
 & + \text{other terms}
 \end{aligned} \tag{B6}$$

$$\text{where } L\Delta G_N = g(s) = \int_0^{\infty} \exp(-\rho_i t) \Delta G_N(t) dt, \quad i = 1, 2, \tag{B7}$$

$$\Omega_2 = (s - \rho_2)(\rho_2 - \rho_1)(\rho_2 - \rho_3),$$

$$\Omega_3 = (s - \rho_3)(\rho_3 - \rho_1)(\rho_3 - \rho_2).$$

In (B6), (B5) is decomposed into three parts, each consisting of elements associated with one characteristic root of (3.50). Elements associated with the stable negative root ρ_1 (indicated by "other terms") are ignored.⁶⁰ This is because that the elements of the function associated with the unstable roots are not convergent as $t \rightarrow \infty$. Convergent solutions for the initial values of the jump variables require that such non-convergent elements be removed. The way to do so will become clear soon.

The next step is to find the original function by inverting the transform (B6). Using Theorem 2 and inverse transform rule:

$$L^{-1}f\left(\frac{1}{s-a}\right) = F(t)e^{at},$$

the inverse of (B6) is obtained as:

$$\begin{aligned} L^{-1}\Delta q(s) = & \frac{1}{\Omega_2}([(\rho_2 - c_{22})\rho_2 - c_{32}f_{23}](\Delta \bar{q} + d_{12}g_2) + [c_{13}f_{32} + c_{12}\rho_2]d_{22}g_2 \\ & + [c_{12}f_{23} + c_{13}(\rho_2 - c_{22})](\Delta \bar{E} + d_{32}g_2)) \exp(\rho_2 t) \\ & + \frac{1}{\Omega_3}([(\rho_3 - c_{22})\rho_3 - c_{32}f_{23}](\Delta \bar{q} + d_{13}g_3) + [c_{13}f_{32} + c_{12}\rho_3]d_{22}g_3 \\ & + [c_{12}f_{23} + c_{13}(\rho_3 - c_{22})](\Delta \bar{E} + d_{33}g_3)) \exp(\rho_3 t) \\ & + \text{other terms} \end{aligned} \quad (\text{B8})$$

⁶⁰In Chapter III, $\rho_1 < 0 < \rho_2 < \rho_3$ is assumed for the model

$$\text{where } g_i = L^{-1}(\Delta G_N(s_i)), \quad i = 2, 3. \quad (\text{B9})$$

(B9) is the inverse transform of (B7)

It is useful to have a specific function for the fiscal policy innovation, which will help to solve for initial values. Suppose that the government takes an once-and-for-all increase in its purchase of nontraded goods by k units, a description of this kind of policy change can be found in the Unit Step Function or Heaviside's unit function.⁶¹

$$\Delta G_N = k\mu_T(t), \quad \mu_T(t) = \begin{cases} 0 & 0 \leq t < T \\ 1 & t \geq T \end{cases}, \quad (\text{B10})$$

where $\mu_T(t)$ is the unit step function that equals zero before T and one at and after T when the policy is implemented. In the special case where the policy is unanticipated, $\mu = 1$ at $t = T = 0$

The last step is to obtain solutions for $\Delta q(0)$ and $\Delta E(0)$. The convergent solution for Δq requires that elements associated with the unstable roots be removed, which may be done by setting expressions in the two curly braces of (B8) equal to zero. Thus, (B8) produces two linear algebraic equations that can be solved for $\Delta \bar{q}$ and $\Delta \bar{E}$ simultaneously:

$$\begin{aligned} \Delta \bar{q} = & \frac{\chi}{\Sigma} k(c_{23}c_{32}d_{11} + c_{13}c_{32}d_{21} + c_{12}c_{23}d_{31})(c_{12}c_{23} - c_{13}c_{22}) \\ & + \frac{\chi}{\Sigma} k[c_{13}d_{11}(\rho_2 - \rho_3) + c_{13}^2d_{31}](\rho_2 - c_{22})(\rho_3 - c_{22}) \end{aligned}$$

⁶¹See Spiegel (1992), VII on p 8 and Special Laplace Transforms No. 139 on p.254

$$+ \frac{\chi}{\Sigma} k c_{12} f_{23} d_{11} [\rho_2(\rho_2 - c_{22}) - \rho_3(\rho_3 - c_{22})] \quad (\text{B11})$$

$$+ \frac{\chi}{\Sigma} k [c_{23} d_{21} (c_{12}^2 - c_{13}^2) - c_{23} c_{13} c_{32} d_{11} - c_{12} c_{13} c_{22} d_{21}] (\rho_2 - \rho_3),$$

$$\Sigma = ([c_{12}(\rho_2 - c_{22})(\rho_3 - c_{22}) - c_{23}(c_{12}f_{22} - c_{32}f_{12})](\rho_2 - \rho_3) + c_{12}f_{23}(\rho_3^2 - \rho_2^2)) < 0,$$

$$\chi = \exp(-\rho_2 t) - \exp(-\rho_3 t) > 0,$$

where $c_{13} < 0$, $c_{22} < 0$, $d_{21} < 0$ and $\rho_2 < \rho_3$. Thus, the second and the fourth terms on the right-hand side of (B11) are unambiguously negative, the third term is unambiguously positive. The sign of the first term is ambiguous because $(c_{12}c_{23} - c_{13}c_{22})$ could be positive or negative. If it is negative, the first term on the right-hand side is negative. Then, at $t > 0$, $\Delta \bar{q} < 0$, which means the announcement of a fiscal expansion at home produces an immediate decrease in the world equity price differential. $\Delta E(0)$ may be solved in a similar way

REFERENCES

- Abel, A.B. and O.J. Blanchard, (1983) "An Intertemporal Model of Saving and Investment," *Econometrica*, Vol. 51: 673-692.
- Aderhold, R., C. Cumming and A. Harwood, (1988) "International Linkages among Equities Markets and the October 1987 Market Break," *Federal Reserve Bank of New York, Quarterly Review*, Vol. 13, No. 2: 34-45.
- Adler, M. and S. Dumas, (1983) "International Portfolio Choice and Corporate Finance, A Synthesis," *The Journal of Finance*, Vol. 38: 925-984.
- , (1986) "Exchange Risk Surprises in International Portfolio," *Journal of Portfolio Management*, Vol. 12, No. 2: 44-53.
- Aggarwal, R. and D.C. Schirm, (1992) "Balance of Trade Announcements and Asset Prices: Influence on Equity Prices, Exchange Rates, and Interest Rates," *Journal of International Money and Finance*, Vol. 11: 80-95.
- Ahtiala, Pekka, (1987) "Effect of Foreign Disturbances under Flexible Exchange Rates," *Journal of International Money and Finance*, Vol. 6: 387-400.
- Ambler, Steve, (1988) "Fiscal and Monetary Policy in an Open Economy with Staggered Wages," *Weltwirtschaftliches Archiv*, Vol. 124: 59-73.
- , (1989) "International Transmission of Policy Announcement Effects," *Journal of International Money and Finance*, Vol. 8: 219-232.
- Ammer J. and J.P. Mei, (1993) "Measuring International Economic Linkages with Stock Market Data," *Board of Governors of the Federal Reserve System, International Finance Discussion Papers*, No. 449.
- Aoki, Masanao, (1981) *Dynamics of Open Economics*, San Francisco: Academic Press.
- , (1986) "Dynamic Adjustment Behavior to Anticipated Supply Shocks in a Two-Country Model," *The Economic Journal*, Vol. 96: 80-100.
- Asprem, M., (1989) "Stock Prices, Asset Portfolios and Macroeconomic Variables in Ten European Countries," *Journal of Banking and Finance*, Vol. 13: 589-612.
- Bailey, W., (1989) "The Effect of U.S. Money Supply Announcement on Canadian Stock, Bond and Currency Prices," *Canadian Journal of Economics*, Vol. 22: 607-618.

- , (1990) "US money Supply Announcement and Pacific Rim Stock Markets Evidence and Implications," *Journal of International Money and Finance*, Vol. 9 344-356
- Bailey, W. and R.M. Stulz, (1990) "Benefits of International Diversification The Case of Pacific Basin Stock Markets," *The Journal of Portfolio Management*, Vol. 16, No 4: 57-61.
- Banerjee, A., J.J. Dolado, J.W. Galbraith and D.F. Hendry, (1993) *Co-integration, Error Correction, and the Econometric Analysis of Non-Stationary Data*, Oxford University Press.
- Baxter, M., and M.J. Crucini, (1993) "Explaining Saving-Investment Correlation," *American Economic Review*, Vol. 83: 416-436.
- Bennett, P. and J. Kelleher, (1988) "The International Transmission of Stock Price Disruption in October 1987," *Federal Reserve Bank of New York, Quarterly Review*, Vol. 13: 17-33.
- Berglas, E. and A. Razin, (1973) "Real Exchange Rate and Devaluation," *Journal of International Economics*, Vol. 3: 179-192.
- Bhandari, J.S. and H. Genberg, (1989) "Exchange Rate Movements and International Interdependence of Stock Markets," *IMF Working Papers*, No 44
- Blanchard, Olivier J., (1981) 'Output, the Stock Market, and Interest Rates,' *American Economic Review*, Vol. 71: 132-143.
- Blanchard, O. J. and S. Fischer, (1981) *Lectures on Macroeconomics*, Cambridge, MA The MIT Press.
- Bollerslev, Tim, (1986) "Generalized Autoregressive Conditional Heteroskedasticity," *Journal of Econometrics*, Vol. 31: 307-327.
- Bollerslev, T., R.Y. Chou and K.F. Kroner, (1992) "ARCH Modeling in Finance, a Review of the Theory and Empirical Evidence," *Journal of Econometrics*, Vol. 52: 5-59
- Boothe, P., K. Clinton, A. Cote and D. Longworth: (1985) *International Assets Substitutability: Theory and Evidence for Canada*, Ottawa, Bank of Canada
- Bordo, M.D. and A.J. Schwartz, (1988) "Transmission of Real and Monetary Disturbance under Fixed and Floating Exchange Rate," *Cato Journal*, 451-472

- Boyer, R. and R. J. Hodrick, (1982) "The Dynamic Adjustment Path for Perfectly Foreseen Changes in Monetary Policy," *Journal of Monetary Economics*, Vol. 9: 185-201.
- Branson, W. H., (1981) "Comments: The Collapse of Purchasing Power Parity in the 1970s," *European Economic Review*, Vol. 16: 167-171.
- Branson, W. H. and D. W. Henderson, (1985) "The Specification and Influence of Asset Market," in R. W. Jones and P. B. Kenen, eds., *Handbook of International Economics*, Vol. 2, Amsterdam: North-Holland.
- Branson, W. H., A. Fraga and R. A. Johnson, (1986) "Expected Fiscal Policy and the Recession of 1982," *NBER WP*, No. 1784.
- Brock, P. L., (1988) "Investment, the Current Account and the Relative Price of Non-traded Goods in a Small Open Economy," *Journal of International Economics*, Vol. 24: 235-253.
- Brock, W. A. and A. G. Malliaris, (1989) *Difference Equations, Stability and Chaos in Dynamic Economics*, New York: North-Holland.
- Brown, S. and J. Warner, (1985) "Using Daily Stock Returns: The Case of Event Studies," *Journal of Financial Economics*, Vol. 14: 3-31.
- Buiter, W. H., (1981) "Time Preference and International Lending in an Overlapping Generation Model," *Journal of Political Economy*, Vol. 89: 769-797.
- , (1986) "Macroeconomic Policy Design in an Interdependent World Economy, an Analysis of Three Contingencies," *IMF Staff Papers*, Vol. 33: 541-582.
- Burdekin, R. C. K., (1989) "International Transmission of US Macroeconomic Policies," *Journal of International Money and Finance*, Vol. 8: 401-423.
- Campbell, J. Y. and R. J. Shiller, (1988) "Stock Prices, Earnings and Expected Dividends," *The Journal of Finance*, Vol. 63: 661-676.
- Campbell, J. Y. and Y. Hamao, (1992) "Predictable Stock Returns in the United States and Japan: A Study of Long-Term Capital Market Integration," *The Journal of Finance*, Vol. 47: 3-70.
- Caprio, G. Jr., and D. H. Howard, (1984) "Domestic Saving, Current Accounts, and International Capital Mobility," *International Finance Discussion Paper 244*, Washington: Board of Governors of the Federal Reserve System.

- Carlozzi, N and J B Taylor, (1985) "International Capital Mobility and the Coordination of Monetary Rules," J Bhandari, ed , *Exchange Rate Management under Uncertainty*, Cambridge, MA The MIT Press
- Chen, N , R Roll and S A Ross, (1986) "Economic Forces and the Stock Market," *The Journal of Finance*, Vol 46 529-554
- Churchill, R V , (1958) *Operational Mathematics*, 2nd ed , New York McGraw-Hill Book Company
- Cooley, T F and S F LeRoy, (1985) "Atheoretical Macroeconometrics, A Critique," *Journal of Monetary Economics*, Vol 16 283-308
- Cornett, M M and H Tehreanian, (1990) "An Examination of the Impact of the Garn-St Germain Depository Institutions Act of 1982 on Commercial Banks and Savings and Loans," *The Journal of Finance*, Vol 45 95-111
- Cumby, R E and F S Mishkin, (1986) "International Linkage of Real Interest Rates the European-US Connection," *Journal of International Money and Finance*, Vol 5 5-23
- Darby, M.R., (1983) "International Transmission Under Pegged & Floating Exchange Rate, an Empirical Comparison," in J S Bhandari et al ed , *Economic Interdependence and Flexible Exchange Rates*, Cambridge, MA The MIT Press
- Devereux, M B , (1991) "Capital Accumulation and the Current Account in a Two-Country Model," *Journal of International Economics*, Vol 30 1-25
- Dickey, D A , D W Jansen and D L Thornton, (1991) "A Primer on Cointegration with an Application to Money and Income," *Federal Reserve Bank of St. Louis*, Vol 73, No 2: 58-78
- Dooley, M P., J.A. Frankel and D J Mathieson, (1987) "International Capital Mobility What Do Saving-Investment Correlations Tell Us," *IMF Staff Papers*, Vol 34 503-30
- , (1989) "Capital Flow Controls, International Asset Pricing and Investors Welfare Multi-country Frame Work," *The Journal of Finance*, Vol 44 1025-1237
- Dooley, M P and P Isard (1980) "Capital Controls, Political Risk and Deviations from Interest Rate Parity," *Journal of Political Economy*, Vol 88 370-384
- Dornbusch, R., (1975) "A Portfolio Balance Model of the Open Economy," *Journal of Monetary Economics*, Vol 1 3-20

- , (1976) "Expectations and Exchange Rate Dynamics," *Journal of Political Economy*, Vol. 84: 1161-1176.
- , (1980) *Open Economy Macroeconomics*, New York: Basic Books, Inc.
- , (1983) "Flexible Exchange Rates and Interdependence," *IMF Staff Papers*, Vol. 30: 3-38.
- , (1988) *Exchange Rates and Inflation*, Cambridge, MA: The MIT Press.
- Dornbusch, R. and S. Fischer, (1980) "Exchange Rate and the Current Account," *American Economic Review*, Vol. 70: 960-971.
- Dwyer, G.P. and R.W. Hafer, (1988) "Are National Stock Markets Linked?" *Federal Reserve Bank of St. Louis*, Vol. 70, No.4: 3-14.
- Engle, R.F., (1982) "Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation," *Econometrica*, Vol. 50: 987-1007.
- Engle, R.F., D.F. Hendry and J.F. Richard, (1983) "Exogeneity," *Econometrica*, Vol. 53: 277-304.
- Engle, R.F. and C.J. Granger, (1987) "Cointegration and Error Correction: Representation, Examination and Testing," *Econometrica*, Vol. 55: 251-276.
- Eun, C.S. and S. Shim (1989) "International Transmission of Stock Market Movements," *Journal of Financial and Quantitative Analysis*, Vol. 24: 241-256.
- Facts on File, Inc., *Facts on File*, various issues, New York.
- Feldstein, M. and C. Horioka, (1980) "Domestic Saving and International Capital Flows," *The Economic Journal*, Vol. 90: 314-329.
- Feldstein, M. (1983) "Domestic Saving and International Capital Movement in the Long-run and Short-run," *European Economic Review*, Vol. 21: 129-151.
- Fenn, G.W. and R.A. Cole, (1994) "Asset-Equity Problem and Contagion Effects," *Journal of Financial Economics*, Vol. 35: 184-198.
- Fleming, M., (1962) "Domestic Financial Policies under Fixed and Floating Exchange Rates," *IMF Staff Papers*, Vol. 9: 369-379.
- Frankel, Jeffrey A., (1986) "International Capital Mobility and Crowding-out in the U.S.

Economy: Imperfect Integration of Financial Markets or of Goods Markets", in R. Hafer ed., *How Open Is the U.S. Economy?* Lexington, MA: Lexington Books

-----, (1989) "International Financial Integration, Relations among Exchange Rates and Interest Rates, and Monetary Indicators," in C. Pigott, ed., *International Financial Integration and Monetary Policy*, New York: Federal Reserve Bank of New York.

-----, (1992) "Measuring International Capital Mobility: A Review," *The American Economic Review Paper and Proceedings*, Vol. 82: 197-202.

Frenkel, J.A. and M. Mussa, (1985) "Asset Markets, Exchange Rates, and the Balance of Payments," in R.W. Jones and P.B. Kenen eds. *HandBook of International Economics*, Vol. 2. Amsterdam: North-Holland.

Friedman, M. and A. Schwartz, (1982) *Money, Interest Rates, and Prices in the United States and United Kingdom: 1867-1975*, Chicago: University of Chicago Press

Gavin, Michael, (1989) "The Stock Market and Exchange Rate Dynamics," *Journal of International Money and Finance*, Vol. 8: 181-200

Giavazzi, F. and M. Pagano, (1985) "Capital Controls and European Monetary System" in *Capital Controls and Foreign Exchange Legislation*, Occasional Paper, Milano: Euromobiliare.

Golub, S.S., (1990) "International Capital Mobility: Net versus Gross Stock and Flows," *Journal of International Money and Finance*, Vol. 9: 424-439

Gould, J.P., (1968) "Adjustment Cost in the Theory of Investment of the Firm", *Review of Economic Studies*, Vol. 35: 47-56.

Grilli, V., (1989) "Financial Market and 1992," *Brookings Papers on Economic Activity*, No.2: 301-311.

Grossman, G.M. and J.A. Levinsohn, (1989) "Import Competition and the Stock Market Return to Capital," *American Economic Review*, Vol. 79: 1065-1087.

Grubel, H.G., (1968) "Internationally Diversified Portfolios: Welfare Gains and Capital Flows," *American Economic Review*, Vol. 58: 1299-1314.

Grubel, H.G., and K. Fadner, (1971) "The Interdependence of International Equity Markets," *The Journal of Finance*, Vol. 26: 89-94

- Hamburger, M J , and L A Kochin, (1972) "Money and Stock Prices: the Channels of Influence," *The Journal of Finance*, Vol. 27: 231-249.
- Hamilton, J D , (1994) *Time Series Analysis*, Princeton, NJ Princeton University Press.
- Hamao, Y , R.W Masulis and V. Ng (1990) "Correlations in Price Changes and Volatility across International Stock Markets," *The Review of Financial Studies*, Vol. 3: 281-307.
- Haque, N.U, and P. Montiel, (1990) "Capital Mobility in Developing Countries-Some Empirical Tests," *IMF Working Paper*, No.90.
- Hartingan, J C., P.R. Perry and S Kamma, (1986) "The Value of Administered Protection: A Capital Market Approach," *The Review of Economics and Statistics*, Vol. 68: 610-617
- Hartman, D.G., (1984) "The International Financial Market and U.S. Interest Rates," *Journal of International Money and Finance*, Vol. 3: 91-103.
- Hayashi, F., (1982) "Tobin's Marginal q and Average q: A Neoclassical Interpretation," *Econometrica*, Vol. 50: 213-224.
- , (1984) "Exchange Market Intervention Operations: Their Effects and Their Role in Financial Policy," in J.F.O. Bilson and R.C. Marston, eds, *Exchange Rate Theory and Practice*, NBER, Cambridge.
- Henderson, D and K. Rogoff, (1982) "Negative Net Foreign Asset Positions and Stability in a World Portfolio Balance Model," *Journal of International Economics*, Vol. 13: 85-104.
- Hilliard, J.E., (1979) "The Relationship between Equity Indices on World Exchanges," *The Journal of Finance*, Vol. 34: 103-114.
- Jeon, B N., and G.M. von Furstenberg, (1990) "Growing International Comovement in Stock Price Indexes," *Quarterly Review of Economics and Business*, Vol. 30: 15-30.
- Johansen, Soren, (1988) "Statistical Analysis of Cointegration Vectors," *Journal of Economic Dynamics and Control*, Vol. 12: 231-54.
- , (1991) "Estimation and Hypothesis Testing of Cointegration in Vectors Gaussian Autoregressive Models," *Econometrica*, Vol. 59: 1551-1580.
- Johnson, D R. and L.L. Schembri, (1990) "Atheoretical and Structural Approaches to

Modelling Canadian-American Macroeconomic Interaction," *Empirical Economics*, Vol. 15: 367-381.

Jones, R.W. and P.B. Kenen, (1984) *Handbook of International Economics*, Amsterdam North-Holland

Jorgenson, D.W., (1963) "Capital Theory and Investment Behavior," *American Economic Review*, Vol. 53: 47-56.

Kaplanis, E.C., (1988) "Stability and Forecasting of the Comovement Measures of International Stock Market Returns," *Journal of International Money and Finance*, Vol. 7: 63-75.

Kasa, Kenneth, (1992) "Common Stochastic Trends in International Stock Markets," *Journal of Monetary Economics*, Vol. 29: 95-124.

Kim, S.W. and J.H. Rogers, (1993) "International Stock Price Spillovers and Market Liberalization: Evidence from Korea, Japan, and the United States," Circulation Paper, State University of Pennsylvania.

King, M. and S. Wadhvani, (1990) "Transmission of Volatility between Stock Markets," *The Review of Financial Studies*, Vol. 3: 5-33.

Koch, P.D. and T.W. Koch, (1991) "Evolution in Dynamic Linkages across Daily National Stock Indexes," *Journal of International Money and Finance*, Vol. 10: 231-251.

Levin, J.H., (1989) "On the Dynamic Effects of Monetary and Fiscal Policy under Floating Exchange Rate: Simulations with an Asset Market Model," *Weltwirtschaftliches Archiv*, Vol. 125: 665-680.

Levy, H., and M. Sarnat, (1970) "International Diversification of Investment Portfolios," *American Economic Review*, Vol. 60: 668-675.

Lessard, D.R., (1974) "World, National and Industry Factors in Equity Returns," *The Journal of Finance*, Vol. 29: 379-391.

-----, (1976) "World, Country and Industry Relationships in Equity Returns: Implication for the Risk Reduction through International Diversification," *Financial Analysts Journal*, Vol. 32, No. 1, 32-38.

Lin, W.L., R.F. Engle and T. Ito, (1994) "Do Bulls and Bears Move across Borders? International Transmission of Stock Returns and Volatility," *The Review of Financial Studies*, Vol. 7: 507-538.

- Lipton, D and J Sachs, (1983) "Accumulation and Growth in a Two-Country Model," *Journal of International Economics*, Vol 15 135-159
- Lucas, R E , (1967) "Adjustment Cost and the Theory of Supply," *Journal of Political Economy*, Vol 75 321-334
- (1982) "Interest Rate and Currency Prices in a Two-Country World," *Journal of Monetary Economics*, Vol 9 335-360
- Malliaris, A G and J L Urrutia, (1992) "The International Crash of October 1987. Causality Tests," *Journal of Financial and Quantitative Analysis*, Vol. 27 353-364
- Mills, T C and A G Mills, (1991) "The International Transmission of Bond Market Movement," *Bulletin of Economic Research*, Vol 43 273-281
- Milbourn, R and H A. Moore, (1986) "Some Statistics Evidence on the Effects of Financial Innovation," *The Review of Economics and Statistics*, 521-526.
- Mishkin, Frederic, (1984a) "Are Real Interest Rates Equal across Countries? An Empirical Investigation of International Parity Conditions," *The Journal of Finance*, Vol 39 1345-1358
- , (1984b) "The Real Interest Rate A Multi-Country Empirical Study," *Canadian Journal of Economics*, Vol. 17. 283-311
- Mundell, R A (1968) *International Economics*, New York Macmillan Publishing Co
- Murphy, R G , (1984) "Capital Mobility and the Relationship between Saving and Investment Rates in OECD Countries," *Journal of International Money and Finance*, Vol 3 327-342
- , (1989) "Stock Prices, Real Exchange Rates, and Optimal Capital Accumulation," *IMF Staff Papers*, Vol. 36. 102-129.
- Mussa, Michael, (1977) "External and Internal Adjustment Cost and Theory of Aggregate and Firm Investment," *Economica*, Vol 44 163-178
- , (1984) "The Theory of Exchange Rate Determination" in J.F O Bilson and R C Marston ed *Exchange Rate Theory and Practice*, Chicago. NBER Conference Report
- Obstfeld, Maurice, (1981a) "Capital Mobility and Devaluation in an Optimizing Model with Rational Expectations," *American Economic Review*, Vol. 71: 217-21.

- , (1981b) "Macroeconomic Policy, Exchange-Rate Dynamics, and Optimal Asset Accumulation," *Journal of Political Economy*, Vol 89 1142-1161
- Obstfeld, M., and K. Rogoff, (1984) "Exchange Rate Dynamics with Sluggish Prices under Alternative Price-Adjustment Rules," *International Economic Review*, Vol 25 159-174
- Obstfeld, Maurice, and Alan C. Stockman, (1985) "Exchange Rate Dynamics," in R. W. Jones and P. B. Kenen, eds., *Handbook of International Economics*, Vol 2, Amsterdam North-Holland, 917-977
- Panton, D., V. Lesseg and O. Joy, (1976) "Comovement of International Equity Markets: A Taxonomic Approach," *Journal of Financial and Quantitative Analysis*, Vol 11 415-432
- Peterson, D. R., (1990) "Stock Return Seasonalities and Earnings Information," *Journal of Financial and Quantitative Analysis*, Vol 25 187-201
- Phelps, E. S., (1989) "New Channels in the Transmission of Foreign Shocks," in G. Calvo, R. Findlay and J. de Macedo, eds., *Debt, Stabilization and Development*, Oxford Blackwell
- Pigott, Charles (1993) "International Interest Rate Convergence: A Survey of the Issues and Evidence," *Federal Reserve Bank of New York, Quarterly Review*, Vol 18 24-37
- Popper, Helen, (1990) "International Capital Mobility: Direct Evidence from Long-Term Currency Swaps," *International Finance Discussion Paper*, Washington: Board of Governors of the Federal Reserve System.
- Remolona, E. M., (1991) "Do International Reactions of Stock and Bond Markets Reflect Macroeconomic Fundamentals?" *Federal Reserve Bank of New York, Quarterly Review*, Vol 16: 1-13
- Roll, Richard, (1988) "The International Crash of October 1987," *Financial Analysts Journal*, Vol. 44, No. 5 19-35
- Ripley, D. (1973) "Systematic Elements in the Linkage of National Stock Market Indices," *The Review of Economics and Statistics*, Vol 55
- Reitzes, J. D. and D. J. Rousslang, (1988) "Domestic versus International Capital Mobility: Some Empirical Evidence," *Canadian Journal of Economics*, Vol 19 312-323
- Sachs, J. D. (1981) "The Current Account and Macroeconomic Adjustment in the 1970s,"

***Brookings Papers on Economic Activity*, 201-268**

- Schollhammer, H and Sand O.C., (1987) "Lead-Lag Relationships among National Equity Markets: An Empirical Investigation" in S.J. Khoury and A. Ghosh ed., ***Recent Developments in International Banking and Finance***, Vol. 1, Lexington, MA: Lexington Books, 151-166
- Schwert, G. Williams, (1990) "Stock Volatility and the Crash of '87," ***The Review of Financial Studies***, Vol. 3: 77-102
- Shiller, R.J., F. Konya and Y. Tsutsui, (1988) "Investor Behavior in the October 1987 Stock Market Crash: The Case of Japan," ***National Bureau of Economic Research***, Working Paper No. 2684.
- Sinn, Stefan, (1992) "Saving-Investment Correlations and Capital Mobility: On the Evidence from Annual Data," ***The Economic Journal***, Vol. 102: 1162-1170.
- Sims, A. Christopher (1980) "Macroeconomics and Reality," ***Econometrica***, Vol. 48: 1-47.
- Spiegel, M.R., (1992) ***Theory and Problems of Laplace Transformations***, Schaum's Outline Series, 24th Printing, New York: McGraw-Hill, Inc
- Stalinger, Michael, (1992) "Standard Errors in Event Studies," ***Journal of Financial and Quantitative Analysis***, Vol. 27: 29-53.
- Stock, J.H. and M.W. Watson, (1988) "Testing for Common Trends," ***Journal of American Statistical Association***, 1097-1107.
- Stockman, A.C. and L. Svensson, (1987) "Capital Flows, Investment, and Exchange Rates," ***Journal of Monetary Economics***, Vol. 19: 171-201.
- Susmel, R. and R. Engle (1994) "Hourly Volatility Spillovers between International Equity Markets," ***Journal of International Money and Finance***, Vol. 13: 3-25.
- Swanson, P.E., (1987) "Capital Market Integration over the Past Decade: The Case of the U.S. Dollar," ***Journal of International Money and Finance***, Vol. 6: 215-25.
- Tesar, Linda, (1991) "Savings, Investment, and International Capital Flows," ***Journal of International Economics***, Vol. 31: 55-78
- Thompson, Aileen, (1993), "The Anticipated Sectoral Adjustment to the Canada-United States Free Trade Agreement: An Event Study Analysis," ***Canadian Journal of Economics***, Vol. 24: 253-271.

- , (1994), "Trade Liberalization and Stock Prices: Evidence from the Canada-US Free Trade Agreement," *Journal of International Economics*, Vol. 37 1-27
- Tobin, J., (1969) "A General Equilibrium Approach to Monetary Theory," *Journal of Money, Credit and Banking*, Vol. 1: 15-29
- Tobin, J., (1983) "Comments on Domestic Saving and International Capital flows in the Long Run and the Short Run by M. Feldstein," *European Economic Review*, Vol. 21 157-159
- Turnovsky, S.J., (1986a) "Monetary and Fiscal Policy under Perfect Foresight: A Symmetric Two Country Analysis," *Economica*, Vol. 53, 139-157
- , (1986b) "Short and Long Term Interest Rates in Monetary Model of a Small Open Economy," *Journal of International Economics*, Vol. 20 291-311
- Turnovsky, S.J. and V. D'Orey, (1986) "Monetary Policies in Interdependent Economies with Stochastic Disturbances: A Strategic Approach," *The Economic Journal*, Vol. 96 696-721.
- Turnovsky, S.J. and P. Sen, (1990) "Fiscal Policy, Capital Accumulation, and Debt in an Open Economy," *NBER Working Paper Series*, No. 3489
- Uzawa, H., (1968) "Time Preference, the Consumption Function, and Optimal Asset Holdings," in J.N. Wolfe, ed., *Value, Capital and Growth: Papers in Honor of Sir John Hicks*, Chicago: Aldine.
- , (1969) "Time Preference and the Penrose Effect in a Two-Class Model of Economic Growth," *Journal of Political Economy*, Vol. 77 628-652.
- von Furstenberg, G.M. and B.N. Jeon, (1989) "International Stock Price Movements: Links and Messages," *Brookings Papers on Economic Activity*, 125-179
- Wasserfallen, W., (1989) "Macroeconomic News and the Stock Market: Evidence from Europe," *Journal of Banking and Finance*, Vol. 13 613-625
- Wong, D.Y., (1990) "What Do Investment-Saving Relationships Tell Us about Capital Movement?" *Journal of International Money and Finance*, Vol. 9 60-74

END

3 1 - 0 5 - 9 | 6

FIN