Economic Shocks, Current Account and Macroeconomic Adjustment : Theory and Practice in Korea

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Declaration

Except where otherwise indicated, this thesis is my own original work.

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Abstract

The main purpose of this thesis is to identify the dynamic effects of exogenous economic shocks on the macroeconomic adjustment in a small open resource-poor economy, Korea. It is well known that the macroeconomic adjustment process of an open economy is best analyzed within an intertemporal general equilibrium framework. However, empirical application of the framework has been very limited despite its theoretical elaborateness.

This thesis provides one of the possible solutions to the apparent problem discussed above. To analyze the effects of exogenous economic shocks on macroeconomic adjustment, an intertemporal general equilibrium model is developed, and the effects of an imported intermediate input price shock as well as various government policy shocks are analyzed. By introducing a risk premium to the real interest rate and imported intermediate input in production process, quite realistic theoretical predictions are obtained about macroeconomic adjustment process.

The basic framework is, then, extended to be applied empirically. At this stage, the role of government is explicitly introduced as a Stackelberg leader against the producer and the consumer. The information structure among the players are assumed to be open-loop. The resulting behavioral decision functions for the three players are econometrically estimated with the assumption of rational expectations. The estimation results of the forward-looking behavioral equations are quite satisfactory.

Additionally, simulation analysis is carried out to identify the quantitative effects of each individual exogenous economic shock. The simulation results are, by and large, consistent with the qualitative results. The main advantage of the simulation analysis was its ability to decompose separate macroeconomic effects according to their causes and origins. The analysis provides a clear picture of how the macroeconomy operates in response to exogenous economic shocks. Among exogenous shocks, the price of imported intermediate input, the world real interest rate and the real wage are shown to have a crucial importance in macroeconomic adjustment process in Korea.

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CHAPTER 1

INTRODUCTION

1.1 Motivation

This thesis is a study of exogenous economic shocks and macroeconomic adjustment in Korea. Exogenous economic shocks refer to any sudden changes in the international economic environment and in domestic economic policies. Over the last two decades, the international economic environment has been quite volatile. The two oil shocks in the 1970s, the debt crisis with sharp increases in real interest rates in the early 1980s and the increasing tendency of protectionism are main examples. The macroeconomic effects of these external shocks, have been very complicated. The adjustment patterns also differed among countries, depending on the openness and resource endowments of the economy as well as the policies implemented in response to the shocks. Moreover, the persistent political instability in the major oil producing countries and the global trade friction in recent years remain as potential sources of external shocks to the resource-poor open developing countries. Adverse developments in the international economic environment cannot be ruled out at any point of time in the future.

It is obvious, therefore, that changes in the international economic environment are of crucial importance especially for a highly open resource-poor economy like Korea. The central question is 'what are the effects of' and 'how to adjust to' a sudden change in the exogenous economic environment whether it is an external shock or the domestic policy change. Adjustment refers to resource reallocation in a Pareto efficient manner after an exogenous economic shock, intersectorally as well as intertemporally. Our main interest is the adjustment in the major macroeconomic aggregates such as consumption, investment, production and the current account.

This thesis aims at identifying the structural relationship between exogenous economic shocks and the macroeconomic adjustment of Korea in a formal framework. It is well recognized that demand-oriented models are inadequate in explaining the effects of an external shock, especially a supply shock. Therefore, aggregate supply side is explicitly incorporated in our analysis. Since adjustment is a time path of behavioral choices, a dynamic intertemporal perspective is important in our analysis. A dynamic intertemporal framework involves several issues such as the treatment of expectations, long-run steady state equilibrium and transitional dynamics. It is particularly useful for the study of macroeconomic adjustment. The role of government is also important since the policy responses to an external shock could induce indirect effects on the economy, and hence make the adjustment more complicated. Interaction between the government and private sectors is also considered.

In addition to the theoretical analysis quantitative analysis is also employed since it allows us to measure the degree of the effects of various shocks. Econometric estimation and simulation approaches are used for this purpose. Empirical application of the forward-looking intertemporal framework is very limited because of its empirical intractability, and hence existing examples are rare. It is especially important that the information structure and the role of future expectations be clarified as prerequisite of the empirical application. This thesis assumes a Stackelberg game between the government and private sectors with an open loop information. The resulting non-linear decision functions of the agents are estimated. The estimated forward-looking aggregate models are then used for simulation of the various exogenous economic shocks including the government policies. Furthermore, the separation of the government and private sector behavior allows us to distinguish the direct effects and the policy-induced (indirect) effects of an external shock.

1.2 Main Issues

This thesis examines the qualitative and quantitative effects of various types of exogenous economic shocks : sudden increases in the price of an imported intermediate

input ; changes in fiscal policy, including a consumption tax, capital and labor income taxes, an investment subsidy and an import tariff. Its main interest is the effects of these shocks on capital formation, production, consumption (saving), the current account and overall macroeconomic adjustment. The main tools of analysis are an intertemporal general equilibrium approach together with econometric estimation and simulation. In the theoretical analysis of this thesis, perfect foresight is assumed. Even if perfect foresight seems to be an extreme assumption, it provides a useful starting point for analysing the behavior of economic agents. In the empirical analysis, however, the assumption of perfect foresight is relaxed to that of rational expectations, and uncertainty about the future is introduced. All this complexity comes from the perception that economic agents' current decisions are influenced by the expectations on the future economic environment as well.

For the Korean economy, the following issues and questions will be examined in this thesis :

A. Production and Factor Substitution

(a) What is the role of imported intermediate inputs in the production side of the Korean economy ? Does an increase in the prices of imported intermediate inputs exert a contractionary effect on value added output ?

(b) How flexible is the production technology in its use of factor inputs ?

(c) What was the role of the government in the adjustment in production after the historical oil shocks ? Was the government policy counteractive to the external shock or not ?

B. Consumption (Saving), Wealth and Expectations

(a) How relevant is a model of forward-looking consumption behavior for the Korean case ? Are expectations on future labor income important and significant in the determination of current consumption ?

(b) If consumption behavior is governed by total lifetime wealth, rather than by current income, can we identify the magnitude of the marginal propensity to consume out of total wealth ?

(c) What are the important factors affecting lifetime wealth, especially human wealth ? In other words, can we identify the consumer's expectation formation mechanism for human wealth ?

(d) Again, what was the role of the government in the consumption adjustment after the two oil shocks ? Was the government policy counteractive or conducive to the adjustment in consumption ?

C. Capital Formation and Expectations

(a) How relevant is the assumption of forward-looking investment behavior for the Korean case ? Are the expectations on future marginal rentals, and hence Tobin's q, significant in the determination of current investment ?

(b) Does a stable expectations mechanism for Tobin's q exist ? What are the major elements affecting Tobin's q and investment in Korea ?

(c) Did investment respond optimally to the increases in the prices of imported intermediate input in the 1970s ?

D. Shocks, External Balance and Adjustment

(a) What are the qualitative and quantitative effects of the main exogenous economic shocks on the current account ?

(b) How was the adjustment in the current account affected by government policies ?

(c) Can we separate the direct effects on macroeconomic adjustment of the oil shocks, for example, from the indirect effects induced by policy changes ?

E. Relationship between the government and Private Sectors

(a) How did the Korean government interact with the private sector ?

(b) Did it respond to the external shocks differently from the private sector ?

(c) What are the important factors determining government policy formation ?

All these questions are confined to the real sector of the economy. The monetary sector and hence the question of inflation are not included. The introduction of money in a satisfactory way, especially in the theoretical analysis, is an area for further research.

1.3 Organization of the Thesis

Chapter 2 outlines the scope of theoretical and empirical issues following this introduction and reviews the relevant previous studies. Since the issue of 'economic shocks and macroeconomic adjustment' is best analyzed in an intertemporal general equilibrium framework, the chapter focusses mainly on intertemporal studies. Along with the analytical review, some stylized empirical observations are discussed and compared.

Chapter 3 discusses the structural performance and macroeconomic adjustment of the Korean economy. The chapter is primarily descriptive and its main purpose is to extract the essential structural features of the Korean economy which will be the framework of later chapters. In particular, the behavior of macroeconomic aggregates such as saving, investment and the current account is described along with the behavior of the government and the main exogenous external shocks experienced.

Chapter 4 derives the current account dynamics generated by an intertemporal optimizing model of saving and investment in an open economy. It introduces a risk premium on foreign borrowing; the resulting negative externality related to the level of external debt provides a dynamic adjustment path of the economy in response to an input price shock which is different to that of the existing literature. For simplicity, chapter 4 focusses only on infinite horizon problems in an open economy and the analytical complications created by the existence of the government sector are postponed until chapter 5.

Chapter 5 extends the basic model of chapter 4 by introducing balanced budget fiscal policies. The fiscal policies analyzed are a proportional tax on consumption (VAT), a proportional tax on capital income, a proportional tax on labor income, a proportional

subsidy on investment and a proportional tax on imports. The chapter shows the positive effects of each fiscal policy instrument and also the possibility that the pattern of macroeconomic adjustment after external economic shocks can be complicated by the government policies.

Chapter 6 estimates an intertemporal optimizing framework using quarterly Korean data. An open loop Stackelberg game between the government and private sectors is introduced to clarify the interaction between them and the information structure. The resulting decision functions of the agents are estimated, assuming rational expectations about the uncertain future key variables.

Chapter 7 solves the estimated aggregate macroeconomic model of chapter 6, and simulates various effects of exogenous economic shocks. In particular, the chapter decomposes the macroeconomic outcomes after the two oil shock periods into separate components according to their causes and origins. It allows us to identify what portion of the changes in, for example, the current account is driven by the input price shock and what portion is driven by the other factors, such as induced changes in the government policies.

Chapter 8 provides a summary and conclusion.

CHAPTER 2

DYNAMIC BEHAVIOR OF AN OPEN ECONOMY : A Selective Survey on External Balance and Macroeconomic Adjustment

2.1 Introduction

The external balance and macroeconomic adjustment in an open economy has been one of the most important issues of open economy macroeconomics since the 1970s. Among the literature on the open economy macroeconomic models, a strand of theory which incorporates the aggregate supply in the existing demand-oriented framework has been developed over the last two decades.[1] The main motive behind this development has been the recognition that demand-oriented macroeconomic models have limitations in explaining the experiences of current account and macroeconomic adjustment after the two oil-shocks in 1970s. This chapter will survey the issue of external balance and macroeconomic adjustment of an open economy subject to exogenous economic shocks, and hence confine itself to the literature which explicitly takes into account the aggregate supply as well as aggregate demand in a general equilibrium manner. Exogenous economic shocks refer to both external shocks (such as a terms-of-trade deterioration or an oil-price increase) as well as the changes in economic policies.

In considering the issue of 'economic shocks and macroeconomic adjustment', several questions arise concerning the pattern of macroeconomic adjustment in response to changes in the economic environment :

(a) To what extent does the shock directly change the relative prices and wealth in the economy, and thereby induce the resource reallocation to ensure efficient resource

1 See Corden (1987), for the recent developments in macroeconomic theory and the relevance of the theories for developing countries.

allocation ? To what extent does the induced reallocation of the resources affect production, absorption, prices and external balance ?

(b) Given the existence of international capital market, to what degree can an open economy reallocate the resources intertemporally via borrowing/lending in the international capital market ?

(c) How is the adjustment affected by the economic agents' expectations, especially by the attitudes toward the risk ?

(d) What is the role of government in the adjustment process ? If an external imbalance is the outcome of the efficient resource allocation intersectorally and intertemporally, should it cause any concern or require any policy reaction ?

This chapter reviews the relevant previous studies along the above questions and outlines the issues to be examined in this thesis.

2.2 External Shocks and Macroeconomic Adjustment

Findlay and Rodriguez (1977) made an important contribution to the analysis of the intermediate input price shock and macroeconomic adjustment in a small open economy. The price increase in raw materials is a 'resource boom' for the net exporter of raw materials, but a 'resource shock' for the net importer. The macroeconomic effect for the net exporter is known as the 'Dutch Disease' [e.g. Corden and Neary (1982), Bruno (1982) and van Wijnbergen (1984a, 1985a), among others], and that for the net importer can be simplified as 'Stagflation' [e.g. Bruno and Sachs (1985)]. Findlay and Rodriguez (1977), Buiter (1978) and Bruno and Sachs (1979) are examples of early studies on the effects of oil price increases from the importer's perspective. They show that unexpected permanent increase in the oil price leads to a deterioration in the current account when oil input is used in fixed proportion to output [Findlay and Rodriguez (1977)], or limited factor substitution is allowed [Bruno and Sachs (1979)]. However, these analyses do not consider the intertemporal aspects of economic agents' behavior.

2.2.1 Intertemporal Equilibrium Analysis of Saving, Investment and the Current Account

The recent developments in macroeconomic models which incorporate the aggregate supply into the traditional demand-oriented framework have mainly explored the behavioral relationships among the major macroeconomic aggregates : consumption (saving), investment and the external balance (especially, the current account).

These models are, for the most part, based on intertemporal optimizing behavior at the micro-level. The economy is assumed to be composed of identical economic agents endowed with perfect foresight on the future key variables. The economy is also a small open economy, and hence faces exogenously given world prices and interest rates. Therefore, the representative agent can borrow or lend resources internationally at the given world interest rate. With the perfect capital market, the agent chooses optimal time paths of consumption (saving) and investment which maximize the lifetime welfare given the intertemporal budget constraint. Then the natural outcome of intertemporal choices of saving and investment is a current account position which leads to the accumulation of net foreign assets (or debt).[2]

The long-run implications of the simple intertemporal optimization models are straightforward and well-known. If a small open economy has a higher rate of return on capital (and possibly a higher opportunity cost of increased national saving) than the risk-free interest cost, the economy is better off by being a net capital importer. Therefore, it is optimal for the economy to continue investment until the rate of return becomes equal to the interest cost. If a small open economy has a higher time preference rate than the interest cost at a certain point of time, the economy is willing to consume more currently at the expense of future consumption. Of course, the consumption and investment at each point of time should satisfy the intertemporal budget constraint.

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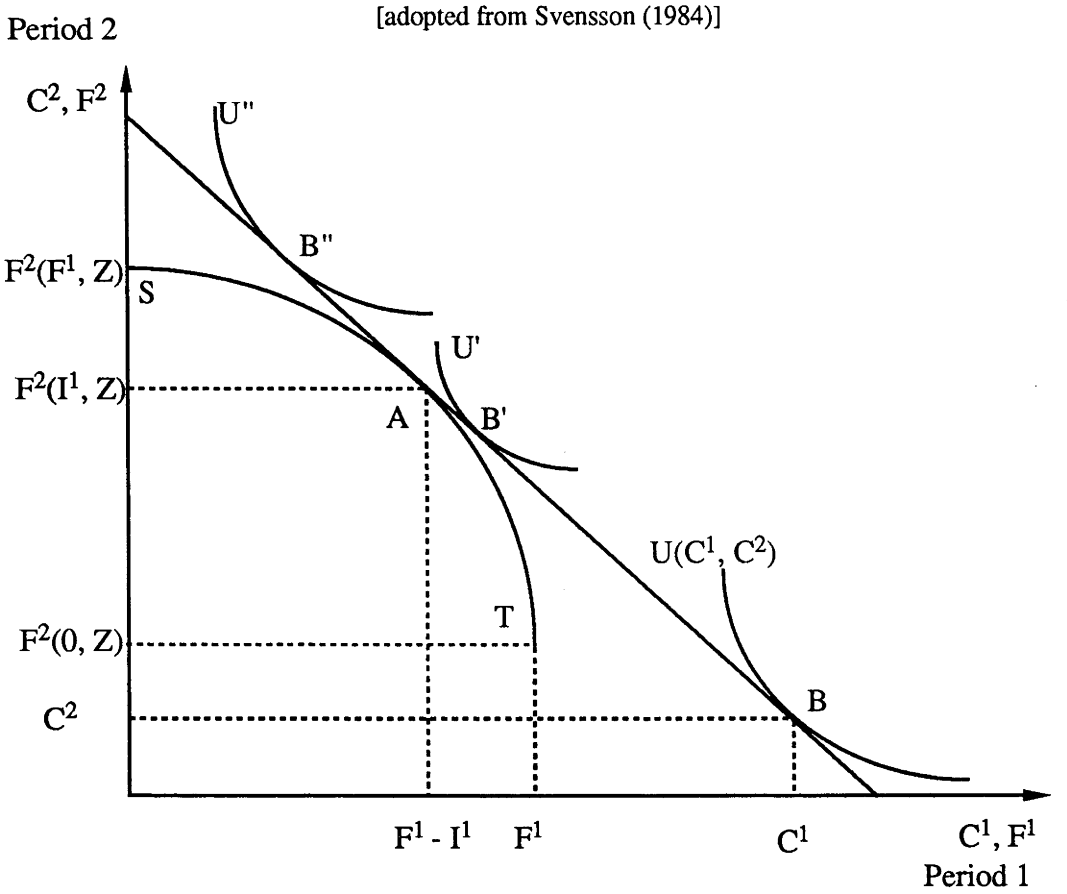
[2] That is, $CA \equiv Y - A \equiv Y - C - I - G \equiv S - I \equiv X - M$. CA is the current account, A is absorption which is the sum of gross domestic expenditures on private consumption (C), government consumption (G), and investment (I). S, X, M denotes saving, exports, and imports respectively. If Y is GNP (GDP), the resulting CA is the current account of goods and services (the current account of goods and non-factor services).

Figure 2.1

Intertemporal Equilibrium in a Small Open Economy
[adopted from Svensson (1984)]



The intertemporal equilibrium analysis on saving/investment and the current account can also be conveniently illustrated by a familiar two-period Fisher diagram as in Figure 2.1, adopted from Svensson (1984). The current output F^1 can be used for present consumption C^1 or investment I^1 for future production. Thus, the second period output F^2 is a function of the present investment if other things (expressed as Z) remain unchanged. The feasible combination of present net output (F^1 - I^1) and future output $F^2(I^1,Z)$ is shown as the intertemporal transformation curve ST. The utility function is shown as an indifference curve $U(C^1,C^2)$ and the intertemporal budget constraint is shown as a line with a slope equal to the discount factor (one over one plus the real rate of interest). The intertemporal optimizing production point (A) determines the level of current investment I^1 and hence the combination of present net output and future output. The intertemporal optimizing consumption point (B) determines the time path of consumption C^1 and C^2. Thus, (dis)saving in period 1 (F^1 - C^1) is given by the

horizontal difference between T and B. Therefore, the current account in period 1 is given by the horizontal distance between A and B, which is the gap between the current saving and investment. In this example (production point A with consumption point B), the economy has a negative saving and a positive investment in period 1 and hence shows the current account deficit. If the preference structure is the utility function U' with the consumption point B', the economy has positive saving and investment with a current account deficit in period 1. Finally, if the preference structure is U" with the consumption point B", the economy has a positive saving which is larger than the positive investment, and hence runs the current account surplus in period 1.

So far we have considered the simple standard case of the intertemporal equilibrium analysis. This intertemporal framework can be applied to investigate the effects of various exogenous economic shocks such as terms of trade deterioration and policy changes. According to the structural and behavioral assumptions adopted, there are several variants of the standard analysis : the time horizon varies from two period to infinite horizon ; some analyses focus only on savings behavior while others focus only on investment behavior ; strategic interaction between economic agents with different objectives can be introduced ; uncertainty and risk factors can be incorporated.

2.2.2 Savings Behavior and Adjustment

Intertemporal choice aspects of savings behavior have been used to analyze oil price/terms-of-trade shocks and the current account. Obstfeld (1982a), Sachs (1981, 1982), Svensson and Razin (1983) and Persson and Svensson (1985), among others, analyze intertemporal savings and the current account. Sachs (1981) and Svensson and Razin (1983) are well-known two-period models of saving and the current account which emphasize the nature of the external shocks. They show that if a terms-of-trade deterioration is temporary, it causes a current account deficit. If, on the other hand, the terms-of-trade deterioration is permanent, the effect is generally ambiguous.

Obstfeld (1982a), Svensson and Razin (1983) and Pitchford (1989) are examples of infinite-horizon models of saving and the current account. Obstfeld (1982a) assumes the time preference rate to be an increasing function of welfare in order to ensure the

stability of the steady-state. A permanent terms-of-trade deterioration in his case leads to increased saving (underspending) and hence a current account surplus, which is opposite to the Harberger-Laursen-Metzler effect. Svensson and Razin (1983) also show that, given the constant real interest rate, the stability of the steady-state requires an increasing time preference rate with the welfare level. That is, when the time preference rate is an increasing function of the welfare, a permanent terms-of-trade deterioration results in a current account surplus. In the case of an unstable steady-state where the time preference rate is a decreasing function of the welfare, on the other hand, a permanent terms-of-trade deterioration leads to an overspending and the current account deficit. The role of varying time preference rate is further discussed in Fane (1987). Pitchford (1989) shows the effects of permanent and temporary terms-of-trade deteriorations in three cases : where the real interest rate is endogenous ; where the time preference rate is endogenous ; where the real interest rate and the time preference rate are endogenous. While the temporary terms-of-trade deterioration leads to ambiguous results, the permanent deterioration results in a current account surplus or does not cause any change in the current account. This is because the consumption falls by the amount equal to or more than the income loss caused by the permanent terms-of-trade deterioration.

Blanchard (1985) provides a very useful finite-horizon framework for analyzing the current account dynamics. By assuming that individuals face a fixed probability of death at each point of time, a private discount rate is shown to exceed the social discount rate. Therefore, it guarantees the existence of a stable steady-state for a small open economy even when the time preference rate is different from the world interest rate. Several researches have adopted this finite-horizon framework [e.g. Buiter (1986a), Frenkel and Razin (1986) and Matsuyama (1987)]. These applications will be discussed later.

However, all the above analyses assume fixed output and do not consider the intertemporal adjustment of investment which is another important factor determining the current account balance and macroeconomic adjustment.

2.2.3 Investment Behavior and Adjustment

Intertemporal investment behavior has also been introduced to provide a more general picture on the determination of the current account and macroeconomic adjustment. Among the two-period models with investment [e.g. Bruno (1982), Svensson (1984), Razin (1984), Marion and Svensson (1984a,b)], Svensson (1984) analyzes the adjustments in saving, investment and employment after an oil price increase. A temporary oil price increase is shown to worsen the current account unambiguously, while a permanent oil price increase is shown to have an ambiguous effect on the current account. Bruno (1982) and Razin (1984) emphasize the role of the real exchange rate and the intersectoral resource shifts in production and consumption. Marion and Svensson (1984a,b) emphasize another dimension of the external shock. They use a three-period model which incorporates investment and analyze the effects of expected and unexpected oil price increases. The unexpected increase in the oil price results in bigger falls in consumption and investment than the expected one. However, the current account outcome is again ambiguous in both cases. van Wijnbergen (1984b) introduces a putty-clay technology into the two-period analysis and shows the optimal response to an oil price increase is an increase in investment with a current account deficit. The increase in investment with current account deficit is the typical pattern of macroeconomic adjustment of developing countries after the first oil-shock. Vegh (1988) shows that if currency substitution is introduced into two-period model, the oil price increase could cause a current account deficit. While all the above analyses assume on full employment, van Wijnbergen (1985b) incorporates disequilibrium in labor and goods market and analyzes classical and Keynesian unemployment cases. The investment and current account responses to oil price shocks are shown to depend on the structure of unemployment and the relative size of the rationing and intertemporal terms-of-trade effects. Despite the benefit of simplicity, however, two-period analysis is unable to describe the transitional dynamics of the macroeconomic aggregates.

Recently some studies [e.g. Abel and Blanchard (1983), Blanchard (1983), Matsuyama (1987), Brock (1988) and Sen and Turnovsky (1989)] have started to incorporate investment dynamics based on a cost of adjustment model [3] in finite or infinite horizon intertemporal analysis. The introduction of adjustment costs in investment leads us to the "q theory" of investment. The q theory introduced by Tobin (1969) argues that firm invests as long as the market value of new additional capital is greater than its replacement cost. In other words, investment continues as long as q, defined as the ratio of the market value to the replacement cost of the capital, is greater than unity. Lucas and Prescott (1971), Abel (1980) and Hayashi (1982a) show that Tobin's q theory is equivalent to a modified neoclassical investment theory with installation costs. Hayashi (1982a), among others, explicitly derives the optimal rate of investment as a function of marginal q adjusted for tax. The implication of the q-theory is that all the relevant information for investment is captured by q, and hence that the higher is q, the greater is the incentive to invest [4] [see Yoshikawa (1980), Wildasin (1984), Edwards and Keen (1985), Chirinko (1987) and McFarland (1988)].

Matsuyama (1987) is an example which incorporates the q-theory of investment into the finite-horizon Blanchard (1985) model. He shows that the current account behavior can be decomposed into wealth effect and portfolio substitution effect. Being a finite-horizon model, saving decision depends on the agent's human wealth while investment decision depends on the agent's portfolio substitution effect. The overall result of oil price shock on the current account depends on the relative magnitudes of these two effects. Brock (1988) introduces a similar investment dynamics into an infinite horizon model and analyzes the effects of fiscal policies on the current account. Sen and Turnovsky (1989) also incorporate investment dynamics in an infinite horizon framework and analyze the effects of terms-of trade shocks. They show that the effects of a terms-of-trade deterioration on the current account depend on the relative size of the (negative)

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[3] The cost of adjustment model was firstly formalized by Eisner and Strotz (1963) and later used by Lucas (1967), Gould (1968), and Treadway (1969).

[4] The information content of the q is still an open question [see McFarland (1988)]. von Furstenberg (1977), Clark (1979), Blanchard and Wyplosz (1981) and Poterba and Summers (1983) show that the empirical estimation of investment on q usually faces large unexplained serially correlated residuals. Abel and Blanchard (1986) show that the aggregation problem, the assumptions of homogeneity of capital and of perfect capital market are the reasons of relatively poor empirical performance of the q theory.

substitution effect and the (positive) income effect on the long run capital stock. When the substitution effect dominates, a permanent deterioration in the terms-of-trade is shown to lead to a long-run reduction in the capital stock. This gives rise to a short-run reduction in investment and a short-run current account surplus. If, on the other hand, the income effect dominates, the deterioration in the terms-of-trade leads to a long-run accumulation in the capital stock, a short-run investment boom and a short-run current account deficit. However, the common problem in these infinite-horizon models is that there is no consumption (saving) dynamics. This is because they assume a constant real interest rate equal to a constant time preference rate to ensure a steady-state. Therefore, consumption is constant over time from the beginning of the planning horizon. All the derived results in their analyses are, therefore, driven by investment rather than saving-investment behavior.

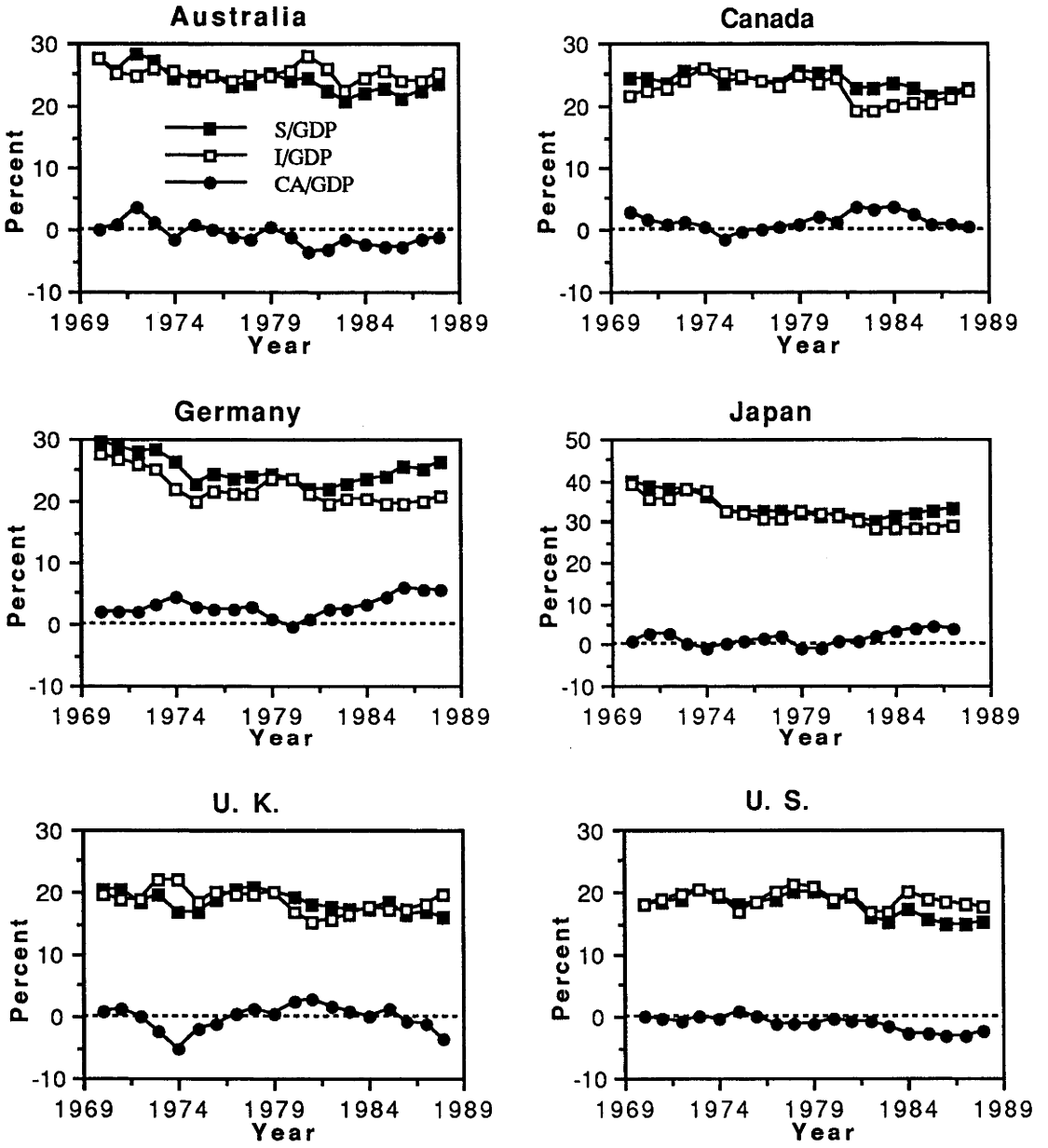
To summarize, the theoretical effects of adverse external shocks such as terms-of-trade deterioration are, in general, ambiguous. The existing simple intertemporal theory predicts that a permanent adverse shock will be matched by an equal fall in consumption, while a temporary shock will not. Similarly, only a permanent adverse shock will reduce investment. The outcome for the current account is a deterioration in the case of a temporary shock, but not in the case of a permanent shock. In the latter case, domestic adjustments will be made by reducing investment and sustaining and/or increasing savings. The effects of an expected or an unexpected adverse shock are also ambiguous. However, if a putty-clay technology or currency substitution are introduced, the permanent adverse shock could result in the current account deficit.

2.2.4 Some Stylized Facts

Before proceeding the discussion further, it is useful to compare the theoretical predictions with some observed experiences of the two oil shocks. Actual experience seems to be mixed as well. Khan and Knight (1983) find that the factors typically identified as having an important influence on the current account positions of the 32

Figure 2.2

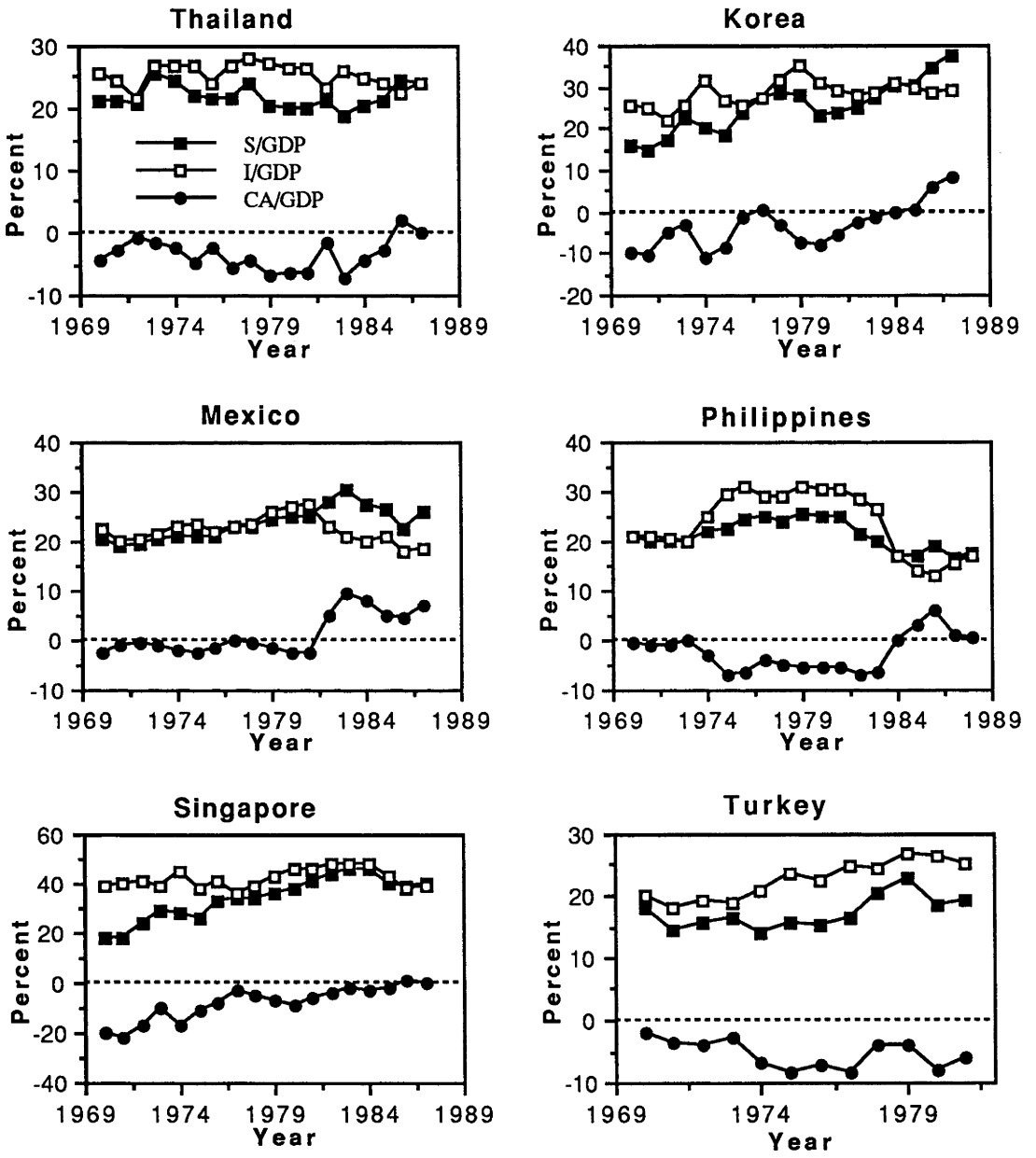
Saving, Investment, and the Current Account Balance, Selected Developed Countries, 1970 ~ 1988 (percent of GDP)



non-oil developing countries in the 1970s are : terms-of-trade, economic activity in the industrialized countries, real interest rate in the international financial markets, fiscal deficit and real effective exchange rate. All of these factors can be categorized into external shocks or policy shocks. Other authors, such as Balassa (1984,1986), Helleiner (1986), and Sachs (1981) investigate the recent experience of the current

Figure 2.3

Saving, Investment, and the Current Account Balance,Selected LDCs, 1970 ~ 1988 (percent of GDP)



account, especially the effects of the external shocks and policy responses to the shocks in developing countries. The stylized facts noted in the empirical literature, some of which can be identified from Figure 2.2 and Figure 2.3, are summarized as follows :

(a) First Oil-Shock : All oil importing countries experienced a current account deterioration. The degree of the current account deterioration, measured as a ratio to

GDP, was larger in the aggregate for the developing countries than for the developed countries. Both investment and saving, measured as ratio to GDP, fell in most developed countries. On the contrary, in most developing countries, a rise in investment surpassed any rise or a fall in savings. On average, continued investment expansion by the developing countries contributed to a further deterioration in their current accounts. Unemployment increased in both developed and developing countries.

(b) Second Oil-Shock : The domestic responses showed different patterns although all oil importing countries again experienced current account deterioration. In most of the developed countries with some exceptions (Australia, Canada), savings and investment fell similarly to the period of the first oil-shock. However, a large proportion of developing countries cut their investment expenditures unlike the period of first oil-shock. The non-oil developing countries, on average, responded to the adverse external shocks by means of investment cuts by roughly the same share of GDP as they had done with consumption cuts during the first oil shock period. In general, unemployment increased in both developed and developing countries. Germany and Japan restored the current account equilibrium quickly after the two oil-shocks.

(c) Most countries experienced accelerated inflation and a slowdown of output growth during both oil-shock periods. Overall, the policy responses of most countries were contractionary except the developing countries responded to the first oil-shock with expansionary policies.

Individual behavior such as consumption or investment seems to be explained partly by the existing literature. However, the overall picture of macroeconomic adjustment differs from country to country in practice and from model to model in theory. It is fair to say that we need a country-specific framework which captures all the specific features of the relevant economy to investigate individual adjustment experience.

2.3 The Role of Government

One possible reason behind the observation that the pattern of macroeconomic adjustment differs among countries can be the different policy response in each country.

Any changes in the government policy in response to an external shock can also be perceived as another exogenous economic shock to the private sector. In such a circumstance, the response to an external shock may well be different from country to country. Therefore, the macroeconomic effects of fiscal policy are of same importance as those of a direct external shock. Unlike the traditional literature on fiscal policy based on the presumption of private market failure, there has been a sizable literature concerning the positive macroeconomic effects of fiscal policy on real macroeconomic variables based on forward-looking behavior about government policies.

Brock and Turnovsky (1981), Abel and Blanchard (1983) and Judd (1985a, 1987) are examples of intertemporal equilibrium analysis with perfect foresight in a closed economy. For the open economy, Aschauer and Greenwood (1985), Buiter (1986a), van Wijnbergen (1986), Frenkel and Razin (1987) and Bovenberg (1989) analyze the effects of fiscal policy changes. The basic intertemporal structures are the same as in the models of terms-of-trade shocks. That is, the intertemporal dimensions of tax policies and their effects on saving, investment, labor supply and growth are emphasized.

Aschauer and Greenwood (1985), among them, discuss the effects of fiscal policy shocks both in the closed-economy and in the open-economy cases. They show that, basically, the response of trade balance in the open economy reacts the same way to various fiscal policy shocks as investment does in the closed economy. Again the nature of the fiscal policy shock, whether it is anticipated or permanent, is emphasized. Anticipated increases in future income tax rate and in future spending leads to an improvement in the trade balance. An increase in public investment leads to a deterioration in the current account.

Bovenberg (1989) explicitly incorporate intertemporal saving and investment to analyze the effects of capital income taxation on trade balance and international competitiveness. It is shown that import shares and intertemporal and intratemporal substitution elasticities are important factors in determining the interaction between saving and investment. If expenditure shares are biased toward domestic goods and the intratemporal elasticities are sufficiently large, a reduction in the capital income tax leads

to a deterioration in the trade balance. The international competitiveness deteriorates in the short run but improves in the long run as results of a reduction in the capital income tax. Interdependency aspects of fiscal policies are dealt with in van Wijnbergen (1986), Buiter (1986b, 1989), Frenkel and Razin (1986,1988) and Giovanni (1988).

In a finite-horizon framework, Blanchard (1985) shows that an increase in the government debt does not affect income but leads the private agent to consume more and dissave, and hence results in the current account deficit. Persson (1985), Fried and Howitt (1988) and Obstfeld (1989) are the examples of overlapping generations model of fiscal policy. Persson (1985) and Fried and Howitt (1988) analyze the effects of fiscal deficit on welfare and the balance of payments. Obstfeld (1989), using a similar model to Persson (1985), introduces two goods and capital accumulation. He shows that factor markets can be a major channel for the communication of fiscal policy to world interest rates, private saving and global asset supplies/distribution.

Regarding the issue of Ricardian Equivalence, there has been a considerable debate. The Ricardian Equivalence, formally modelled by Barro (1974), implies that an increase in current government debt represents merely a shift in the timing of tax collection from the current period to the future. The private sector with perfect foresight does not change its consumption because its lifetime wealth is not changed. Therefore, alternative methods of financing (current tax vs. future tax) a given path of government expenditure have the same real consequences.

However, Ricardian Equivalence requires a number of quite strong assumptions : the existence of perfect capital markets ; a non-distortionary tax structure ; no uncertainty about future taxation and expenditures ; identical planning horizons for private and public sectors [Haque (1988)]. Many studies [Barro (1979), Kydland and Prescott (1980), Lucas and Stokey (1983) and Razin and Svensson (1983)] point out that distortionary taxes result in departures from Ricardian Equivalence. Capital controls [Greenwood and Kimbrough (1985)] and a finite planning horizon [Blanchard (1985)] are shown to be reasons for the non-neutrality of government debt. Haque and Montiel (1987) and Rossi (1988) show that deviations from Ricardian Equivalence in developing economies is mainly due to liquidity constraints.

Recently some papers have started to consider strategic interaction between economic agents with different objectives. The analysis of strategic interaction between agents requires the use of game theory. The application of game theory is found in various fields of economics : international trade policy [e.g. Helpman and Krugman (1989)] ; country risk and international capital movements [e.g. Eaton et. al (1986), and Crawford (1987) for a survey] ; international policy interaction or coordination [e.g. Corden (1985b), McKibbin (1987), Miller and Salmon (1985), Oudiz and Sachs (1984, 1985)] ; interaction between the government and private sectors [e.g. Abou-Kandil and Bertrand (1987), Conway (1987) and Straszak et. al (1986)] ; and interaction between different bodies of a government [e.g. Pindyck (1977)].

Unlike the models surveyed in the previous sections, these game-theoretic models assume separate objective function for each economic agent. According to the information structure and strategy, the games can be divided into several categories. Turnovsky (1985) clarifies various types of strategic behavior :

> "Traditionally, two types of strategic behavior have been analyzed using game theory, namely, noncooperative and cooperative. In the former, each agent acts independently, under alternative assumptions regarding the interaction of his behavior with that of his competitors. The two most common assumptions are : (i) Nash and (ii) Stackelberg behavior. In the former, each agent takes the actions of his competitors as given and reacts to them. .....In the latter mode of policy making, however, there is a dominance and in a two-player game one of the agents plays the role of a 'leader' and the other a 'follower'. .....In determining his equilibrium policy in Stackelberg sense, the leader anticipates possible rational reactions of the follower to his announced policy and optimizes his objective function accordingly" (p. 220).
>
> ".....An information set is said to be open-loop if only the a priori raw data set is available at all points in time ; in this case the policy variables depend only upon time and are called open-loop policies. On the other hand if there is some dynamic evolution of the available information and the policy variables are

allowed to depend upon this dynamic information, the information pattern is said to be closed-loop or feedback" (p. 221).

Miller and Salmon (1985), Oudiz and Sachs (1985) and Currie and Levine (1985), among others, provide comprehensive examples on the various categories of dynamic game. They show the equilibrium solutions for cooperative vs non-cooperative, Nash vs. Stakelberg and open-loop vs. closed-loop games and strategies.

The credibility and time-consistency of government policy has been another important issue in this field of analysis. Kydland and Prescott (1977) show that the optimal policy in a forward looking model would be time-inconsistent and incredible. That is, the policy announced may not be feasible or the government may have an incentive to change the policy. Calvo (1978), Calvo and Obstfeld (1988), Lucas and Stokey (1983) and Persson and Svensson (1984) are other examples on this issue. McKibbin (1988) provides a survey on this issue.

2.4 Uncertainty, Risk and Credit Constraint

When uncertainty is introduced, the economic agent is no longer endowed with perfect foresight. In such a case, the agent does not know whether the external shock such as an oil price hike or policy change is temporary or permanent. Thus, the agent's attitude toward risk plays an important role in this case. For example, a risk-averse agent will not borrow to smooth consumption/investment unlike the case of perfect foresight. Molho (1990) discusses this point :

> ".....Risk aversion is a plausible explanation for the prompt restoration of current account balance in Germany and Japan following the second oil shock. In retrospect, the terms of trade effects of that shock can be deemed to have been temporary and, as such, would have called for a more tolerant view of current account deficits in a world with perfect foresight. At the time, however, policy makers could not possibly anticipate the subsequent collapse of oil prices. As a

result, they rationally opted for minimizing the risk of future consumption possibilities at the expense of lower current consumption" (p. 6).

An individual borrower (e.g. a developing country) also often faces a binding credit constraint and/or an upward sloping supply curve of foreign funds because of default risk, not because of any ability to affect the world wide cost of capital.[5] The rationale for this is that increases in the stock of debt increase the probability of default and hence impose a negative externality to the economy as a whole, by worsening its creditworthiness. Eaton and Gersovitz (1981), Glick (1983), Glick and Kharas (1986), Sachs (1984), Sachs and Cohen (1982) and Cooper and Sachs (1986) specify an interest cost function by deriving it from an explicit consideration of borrowers' defaulting possibilities. The main idea behind these models is that an individual debtor defaults whenever the present discounted benefit of default exceeds the present discounted cost. Then potential lenders, who know the debtor's decision rule, will never lend so much that an obvious incentive to default is created.

Therefore, if default risk and uncertainty are introduced, a positive relationship between the interest rate and the stock of debt outstanding as well as a binding credit ceiling come into consideration. Some empirical studies [e.g. Edwards (1986a)] confirm the positive effect of higher debt ratio on the risk premium. Eaton and Taylor (1986) and Eaton et. al (1986) provide extensive surveys on this topic.

2.5 Empirical Studies

Empirical studies on the effects of supply shocks based on intertemporal and/or game-theoretic analyses are very few because of the difficulty in empirical application of intertemporal analysis. Although there exist some numerical analyses [e.g. Lipton and Sachs (1983)], they are analytical rather than empirical analyses. Most of the empirical studies so far are mechanical decomposition analyses which identify the sources and

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[5] Many studies on trade and growth adopt an upward sloping supply schedule of foreign funds [see Bade (1972), Bardhan (1967), Bruno (1976), Hamada (1969), McCabe and Sibley (1976), Obstfeld (1982b) and Pitchford (1970, 1989)].

effects of supply shocks [e.g. Bacha (1986), Balassa (1984, 1986) and Mitra (1986)]. Despite the benefits of simplicity, they ignore the structural and behavioral relationships of the economy. The decomposition analysis is based on a few constant parameters such as marginal propensity to import out of income, etc..

Goulder, Shoven and Whalley (1983) and Goulder and Eichengreen (1989) are examples of applied computable general equilibrium (CGE) models which incorporate intertemporal elements. The merit of the applied CGE approach is that it can explicitly capture the welfare effects of supply shocks such as intermediate input price hikes. The interaction of energy and economic policies is analyzed in a multi-period general equilibrium framework by Blitzer and Eckaus (1986). Overall, the CGE approach has some attractive merits such as its capability of dealing with multisector economies. However, the CGE approach uses, in general, parameters which are not derived from econometric estimation. Also, except in very few cases, the approach usually lacks any dynamic structure.

For the Korean case, most studies of supply shocks and macroeconomic adjustment do not explicitly introduce the supply side of the economy. Park (1986) and Collins and Park (1989) use the decomposition method to analyze the Korean experiences of the two oil-shocks. While Park (1986) uses Bacha (1986)'s method, Collins and Park (1989) use the Korea Development Institute (KDI) quarterly macroeconomic model for the decomposition analysis. However, the KDI quarterly macroeconomic model is itself a demand-oriented model and hence lacks the aggregate supply side of the economy which is crucial for the analysis of supply shocks.

2.6 Conclusions

There has been great progress in economic theory dealing with the macroeconomic adjustment in response to various exogenous shocks. As shown in the previous sections, the intertemporal equilibrium analysis has provided new insights in understanding the adjustment behavior after supply shocks. Macroeconomic aggregates such as consumption (saving), investment and the current account are the outcomes of

agents' intertemporal choices. Therefore, the current decisions on these behavioral variables depend on the future expectations of key policy (exogenous) variables.

In general, the macroeconomic response to an adverse shock can have any pattern. For instance, if the adverse shock is perceived as a permanent one, simple perfect foresight infinite-horizon model predicts the optimal response to be underspending and a current account surplus. This counter-intuitive result is obtained since the time preference rate is increasing with welfare. When the time preference is decreasing with welfare, the result is reversed with unstable steady-state. A temporary adverse shock may generate a current account deficit.

These patterns of adjustment can be different if the horizon is finite. The attitude toward risk, uncertainty and imperfect capital market can also affect the adjustment pattern. If there are more than two economic agents who have different objectives and policy instruments, the results will be affected according to the information structure and type of strategies employed.

Despite the theoretical elaborateness, the intertemporal analysis has limited empirical application. As a result, empirical studies are both rare and less than satisfactory. Aggregation problems and the need to employ strong assumptions such as rationality or perfect foresight make empirical applications difficult. Moreover, it is hard to find a formal framework which can be used to analyze the specific experience of Korean economy.

This thesis will try to overcome these apparent problems and analyze the experience of Korean adjustment qualitatively and quantitatively. Starting from a simple framework, the role of the government will be explicitly considered so that the possible interactions between the government and the private sectors can be captured. For the empirical analysis, rational expectations about the uncertain future variables are assumed. The structural equations derived from the optimization rules are, then, estimated using the Korean data. In order to obtain more insights into the quantitative effects of the shocks, simulation will be carried out for alternative combinations of the exogenous economic shocks.

CHAPTER 3

THE KOREAN ECONOMY : A Brief Overview of the Structure, Performance and Adjustment

3.1 Introduction

Since 1960s, the Korean economy has shown a substantial transformation in its structure, with a rising share of manufacturing, and a growing importance and a changing composition of trade. Moreover, it has recently managed to reduce the massive external debt by achieving successively smaller current account deficits since 1970s, and current account surpluses from 1986 to 1989.

Therefore, the Korean economy provides an interesting case study of the macroeconomic adjustments in the open developing economy. The economy is heavily dependent on imported intermediate producer goods and capital goods, with a high ratio of trade to GNP. As a trade-dependent and resource-poor economy, it has relied heavily on trade in tradable manufactures to raise its standard of living, and hence remained vulnerable to the uncertainties of the international trade environment and to the external shocks which it cannot control. These features suggest that the macroeconomic performance of Korea is highly sensitive to changes in international trade environment and external shocks. Additionally, the government has played an active role in the economy as a consumer, producer, and regulator, although the government sector and the private sector in the Korean economy have been highly cooperative compared with other developing countries.

The main question is how the historical external shocks have affected the macroeconomy as a whole. To be more specific, how have the government and the private in Korea responded to those external economic shocks ? Can the resulting behavior of macroeconomic aggregates such as consumption, investment and current account be explained in a formal framework ? Recently, there are many studies of the

experience of trade and growth in Korea,[1] each emphasizing different factors or aspects. Of course, no single factor can account for the whole experience, but all of the factors cited in the literature played a role. However, few studies have tried to explain the experience of the current account and macroeconomic adjustments of Korea in a formal framework.

This thesis aims at providing a formal framework. As a preparatory chapter, this chapter purports to overview the macroeconomic performance of Korea, and hence to extract the essential factors which will be the basis for the construction of more formal framework in later chapters. Specifically, the behavior of macroeconomic aggregates (consumption/saving, investment, current account, and income growth) will be examined together with the behavior of government policy and exogenous economic shocks, since the interrelations among them are crucial in determining an economy's equilibrium (both internal and external).

3.2 Macroeconomic Performance and Structure

3.2.1 Saving, Investment, and Macroeconomic Balance

Saving and investment accumulate into financial wealth and capital, respectively. The difference between saving and investment determines the external balance which, in turn, accumulate into external debt or assets. The overall developments of flows (saving, investment, etc.) and stocks (wealth, capital, external assets, etc.) reflect the macroeconomic performance of the economy over time. This section will describe the long-term overview of the Korean economy from this perspective.

Since the 1960s, the Korean economy has shown substantial changes in its absolute size and structure. Table 3.1 summarizes the essential features of the macroeconomic performance and the structural pattern of Korean economy. A quick look at the Table 3.1 reveals the following characteristics :

(a) Real GNP has grown at an annual average rate of 8.6%, with a rapid expansion of the tradable manufacturing sector and a growing share of trade in GNP.

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[1] For an extensive reference, see Dornbusch and Park (1987), pp. 389 -390.

Table 3.1

Macroeconomic Performance and Structural Pattern, Korea, 1953 ~ 1987

(percent)

	1953~60	1961~70	1971~80	1981~87
Growth Rate[a] (average % per year)				
Real GNP	3.7	8.4	8.1	9.7
Gross Fixed Investment	10.6	22.3	12.9	9.7
Consumption	4.3	6.6	7.0	6.9
Exports	9.8	29.0	21.5	14.1
Imports	3.0	20.5	15.3	9.3
Ratio to GNP				
Gross Investment	12.3	19.8	28.3	29.6
Gross Fixed Investment	9.9	18.2	26.6	28.8
National Saving	4.3	10.5	21.0	28.9
Foreign Saving	7.9	9.1	7.0	2.4
Current Account	- 1.5	- 3.6	- 5.2	- 0.4
Exports	2.9	10.6	28.1	37.9
Imports	10.8	19.7	35.0	40.3
External Debt (Gross)	4.3	28.7	45.0	27.7
External Debt (Net)	n.a.	19.7	32.5	17.5
Marginal Capital Coefficients	1.3	2.5	3.0	4.3
Share in GNP				
Agriculture[b]	41.9	35.3	22.5	13.1
Manufacturing[c]	13.4	19.3	27.5	31.6
Others	44.7	45.4	50.0	55.3
Inflation Rate (GNP Deflator)	23.1	17.5	20.0	6.2
Unemployment Rate	-	6.4[d]	4.1	4.0
M2 Growth Rate	-	44.5	30.3	18.3
Ratio of Budget Deficit to GNP	-	3.0[e]	3.0	1.3
Ratio of Tax Burden to GNP	7.6	11.1	15.7	17.7
Labor Share in National Income	32.0	34.7	43.6	45.5

Sources : The Bank of Korea, *National Accounts*, and *Economic Statistics Yearbook*, various issues.

Notes : a Series based on constant prices, 1953 ~ 1970 (1975 prices), 1971 ~ 1980 (1980 prices), and 1981 ~ 1987 (1985 prices), respectively.

b Includes forestry and fishing.

c Includes mining and quarrying.

d 1963 ~ 1970

e 1966 ~ 1970

(b) The investment ratio has risen to a level of 30% from its low level of 12% in the 1960s.

(c) The savings ratio has risen more rapidly than the investment ratio to achieve the balance between saving and investment, although the savings ratio was very low relative to the investment ratio in the early period. Foreign saving (external borrowing) which played very important role in economic growth , has been replaced gradually by the increased national savings.

(d) In the middle of the 1980s, the Korean economy attained overall resource balance as the growth of savings and exports caught up with the growth of investment and imports. At the same time the ratio of external debt to GNP started to decline.

(e) Reflecting the growth-oriented expansionary monetary and fiscal polices, the inflation rates were relatively high until the end of the 1970s. Since the 1980s, however, this trend was reversed as the Korean government adopted the stabilization policies.

(f) Finally, the labor share in national income as well as the capital coefficient has increased continuously, although the latter remained at a relatively low level. The increased factor inputs of both labor (employment) and capital have contributed to the output growth, given the low capital coefficient and high labor productivity.

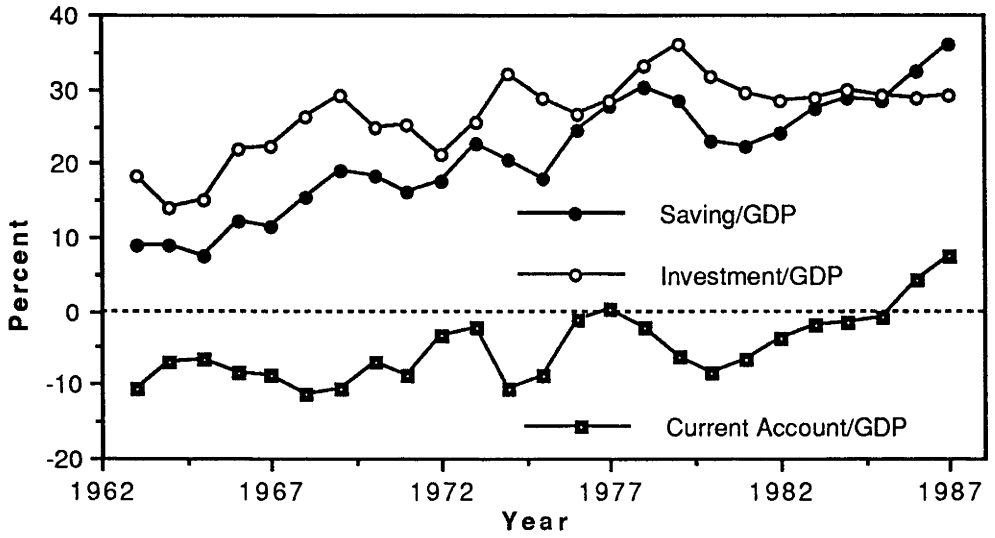
The objectives of the economic development include not only the growth of per capita income, but also employment creation, a more equal distribution of income, and the development of human resources, among others. Korea is no exception.

Table 3.2 and Figure 3.1 show the performance of saving and investment in aggregate and by sector. In the 1950s, before the economic development plan was launched, Korea had severe macroeconomic imbalances. The annual average rate of saving to GDP was only 4.3% ,while the investment rate was 12.3%, on average. The gross investment rate has risen continuously to 25% in the early 1970s, 33% by the end of the 1970s, and remained around 30% throughout the 1980s. For the whole period except the first 5-year plan period, investment exceeded the initial targets of the 5-year economic development plans. Investment was mainly channelled to social overhead capital and to the tradable manufacturing sector for a considerable period, but to service sector later. Given the low level of national savings, foreign saving was inevitable in the

Figure 3.1

Saving, Investment, and Current Account in Korea, 1963 ~ 1987

(percent of GDP)



early stage of development. Naturally, the current account deficit has accumulated to a large amount of external debt until 1985.

The increase in the savings rate was more rapid than that of the investment rate. The ratio of savings to GDP has been doubled from 8.8% in 1963 to 18.5% in 1970, and again doubled during the 1980s. The ratio of exports to GDP has shown a similar trend to the savings rate. Of course, the average real growth rate of consumption since the 1960s was 6.8%, which is lower than the average growth rate of real GNP 8.6%. Without the increase in the savings, the continued investment and growth would not have been possible because of the external balance of payments constraint. The increase in savings has mainly been attributed to the continuous increase in private saving.

What is the force behind the rapid growth of national savings in Korea? Several factors could be mentioned. One would be the financial reforms in 1965, which raised nominal interest rates on deposits from 12% to as high as 26.4% to ensure positive real interest rates. Another important factor would be the rapid growth of the aggregate real income. Rapid growth has raised the savings rate over the whole period. Higher saving

Table 3.2

Savings and Investment, Korea, 1963 ~ 1987

(percent of GDP)

	Private			Government			Total		
Year	I(Inv)	S(Sav)	I-S	I(Inv)	S(Sav)	I-S	I(Inv)	S(Sav)	I-S
1963	14.7	9.1	5.6	3.5	- 0.4	3.9	18.2	8.8	10.5
1964	10.8	8.3	2.5	3.4	0.5	2.9	14.1	8.8	6.9
1965	11.2	5.7	5.5	3.9	1.7	2.2	15.1	7.4	6.5
1966	17.1	9.2	7.9	4.8	2.8	2.0	21.9	12.0	8.6
1967	17.4	7.4	10.0	4.9	4.2	0.7	22.3	11.6	9.0
1968	19.7	9.1	10.6	6.5	6.2	0.3	26.2	15.3	11.3
1969	21.3	13.1	8.2	7.9	6.0	1.9	29.2	19.1	10.8
1970	19.8	12.3	7.5	5.1	6.1	- 1.0	25.0	18.5	7.1
1971	20.7	11.2	9.5	4.5	5.1	- 0.6	25.2	16.3	8.7
1972	17.6	15.2	2.4	3.6	2.3	1.3	21.2	17.4	3.3
1973	22.3	19.7	2.6	3.1	3.0	0.1	25.4	22.8	2.2
1974	29.2	18.3	10.9	2.8	2.1	0.7	32.0	20.4	10.6
1975	25.2	15.6	9.6	3.5	2.5	1.0	28.7	18.1	8.8
1976	23.6	19.9	3.7	3.2	4.6	- 1.4	26.8	24.5	1.1
1977	24.9	23.3	1.6	3.6	4.4	- 0.8	28.5	27.8	- 0.1
1978	29.1	24.9	4.2	3.9	5.3	- 1.4	33.1	30.1	2.1
1979	31.7	22.1	9.6	4.3	6.4	- 2.1	36.0	28.5	6.4
1980	27.2	17.7	9.5	4.5	5.1	- 0.6	31.7	22.9	8.4
1981	25.2	17.1	8.1	4.3	5.3	- 1.0	29.5	22.4	6.5
1982	24.1	18.3	5.8	4.5	5.7	- 1.2	28.6	24.0	3.6
1983	24.3	20.4	3.9	4.5	6.8	- 2.3	28.8	27.2	1.9
1984	25.4	22.5	2.9	4.5	6.4	- 1.9	29.8	28.9	1.5
1985	24.8	22.3	2.5	4.5	6.2	- 1.7	29.3	28.5	1.0
1986	24.8	26.3	- 1.5	3.9	6.1	- 2.2	28.8	32.5	- 4.3
1987	25.4	29.3	- 3.9	3.8	6.8	- 3.0	29.2	36.1	- 7.4

Sources : The Bank of Korea, *National Accounts*, various issues.
Economic Planning Board, *Major Statistics of Korean Economy*, various issues.

Note : Due to the statistical discrepancies, the gap between gross investment and gross saving does not exactly coincide with foreign saving.

has released resources for the investment. In this sense, the important link between saving and investment was not only the current account, but also the income growth. The current account improvement has been achieved mainly by the increase in saving, not by the decrease in the investment.

3.2.2 Trade Structure and Current Account of the External Sector

Table 3.3 shows the developments of the current account in Korea since 1970. The evidence indicates that the external balance does not seem to have been an objective of the first priority, especially in the early stage of development. Although the current account deficit has been one of the concerns of the government, external balance has been sacrificed for growth. The current account deficit has accumulated continuously over this period and its level was more than 10% of GDP in some years. In spite of the continuing deficit, the investment has never been cut below the government target. Reflecting the imbalance between saving and investment, the external debt (total) has increased to 50.3% of GDP in 1985, with a reversal of the trend afterwards. The government budget deficit has hardly been the cause of the current account deterioration over this period.

Another characteristic that can be found in Table 3.3 is that the current account balance in Korea has been dominated by the trade balance which is sensitive to the fluctuations of the relative prices of exports and imports (terms-of-trade). It is clear from Table 3.3 that the surge in imports was the main cause of the current account deterioration while exports showed steady growth during the two oil-shock periods (1974 ~ 75 and 1980 ~ 81). The surge in imports and resulting current account deterioration in those periods were mainly triggered by the terms-of-trade deterioration which the economy cannot control. Figure 3.2 shows that the terms-of-trade deteriorated by 18.6% in 1974 following the first oil-shock, and by 13.3% in 1980 after the second oil-shock. Reflecting the terms-of-trade deterioration, the ratio of current account deficit to GDP recorded 10.6% in 1974, and 8.4% in 1980, respectively. The counterpart to the current account deficit was the increased investment combined with a drop in saving during the first oil-shock period. In the second oil-shock period, however, both investment and

Table 3.3

The External Balance, Korea, 1970 ~ 1987

(percent of GDP)

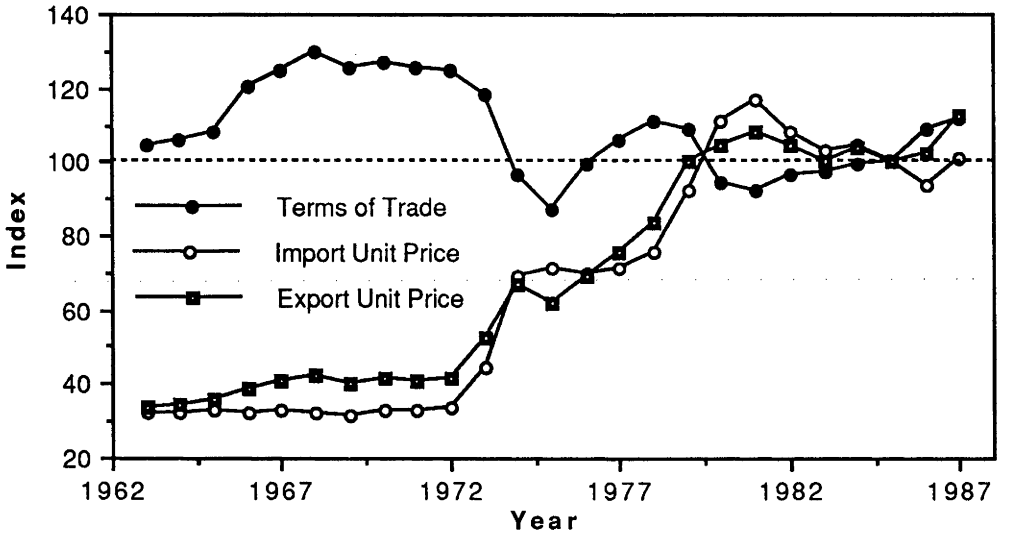
Year	Exports					Imports					Surplus	External Debt
	Goods (fob)	Services	Factor Receipts	Transfers	Total	Goods (cif)	Services	Factor Payments	Transfer	Total		
1970	9.9	4.2	1.5	2.4	18.0	22.2	1.6	0.9	0.4	25.1	-7.1	28.8
1971	11.5	3.9	1.2	2.1	18.7	24.2	1.5	1.3	0.3	27.4	-8.7	30.9
1972	15.6	4.3	1.2	2.1	23.2	23.1	1.4	1.6	0.4	26.5	-3.3	33.6
1973	23.8	5.6	0.9	2.3	32.7	30.9	1.5	1.7	0.8	34.9	-2.2	31.4
1974	23.7	4.1	0.9	1.8	30.5	37.0	1.8	1.9	0.5	41.1	-10.6	31.4
1975	23.8	4.0	0.7	1.7	30.2	33.6	2.6	2.3	0.5	39.0	-8.8	40.0
1976	26.8	4.2	0.6	2.7	34.3	30.5	2.3	1.9	0.6	35.3	-1.1	36.4
1977	26.5	5.1	0.7	2.9	35.1	29.6	2.6	2.2	0.7	35.0	0.1	34.0
1978	24.8	4.9	0.9	3.1	33.6	30.3	2.9	2.2	0.4	35.8	-2.1	28.5
1979	22.5	5.4	0.9	2.3	31.1	31.7	2.9	2.5	0.4	37.5	-6.4	32.6
1980	27.4	6.6	1.1	3.0	38.2	37.4	4.0	4.5	0.6	46.6	-8.4	43.6
1981	29.2	7.3	1.3	3.1	41.0	36.8	4.7	5.4	0.5	47.5	-6.5	46.5
1982	27.1	7.4	1.3	3.6	39.4	32.9	4.2	5.4	0.5	43.0	-3.6	49.8
1983	28.3	7.4	1.1	2.4	39.1	32.3	3.8	4.4	0.5	41.0	-1.9	49.1
1984	29.2	6.7	1.2	2.3	39.5	32.4	3.4	4.7	0.4	41.0	-1.5	47.8
1985	28.5	6.1	1.3	1.6	37.5	30.3	3.0	4.7	0.4	38.4	-1.0	50.3
1986	32.0	6.6	1.2	1.6	41.4	29.7	2.8	4.3	0.3	37.1	4.3	42.0
1987	35.1	6.6	1.0	2.0	44.6	30.9	2.8	3.2	0.4	37.2	7.4	27.1

Sources : The Bank of Korea, *National Accounts*, and *Economic Statistics Yearbook*, various issues.

Figure 3.2

Terms-of-Trade, Korea, 1963 ~ 1988

(1985=100)



saving fell with a larger drop in saving compared to that in investment. Despite the deterioration of the terms-of-trade, the ratio of total imports to GDP did not fall. This reflects the high dependence of the Korean economy on the imported inputs .

Table 3.4 shows that imported producer goods constitute a large part of total imports. The share of intermediate inputs in the total imports has remained at more than 50% over the period, and that of producer goods including capital goods has increased

Table 3.4

Composition of Imports, Korea, 1970 ~ 1988

(percent of total imports)

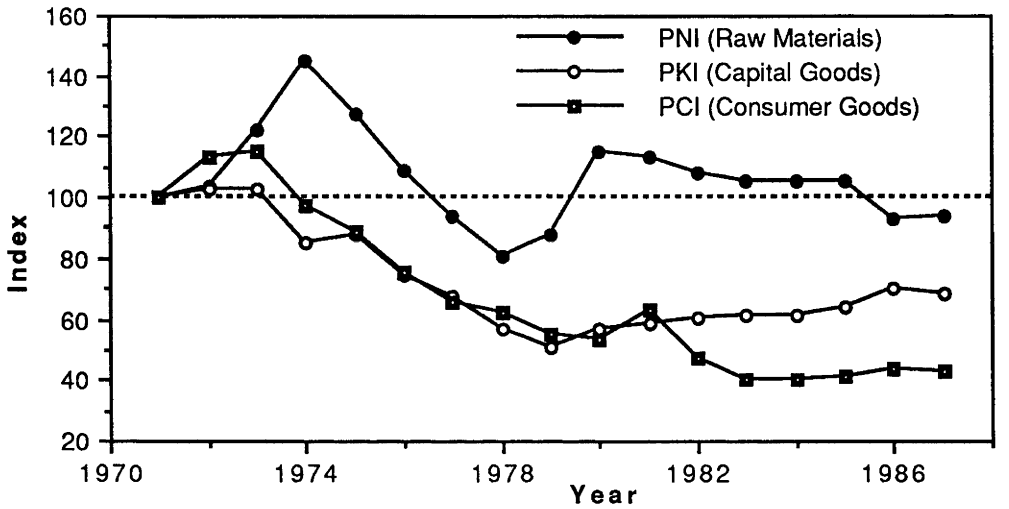
	Producer Goods			Consumer Goods	
Years	Raw Materials	(Oil)	Capital Goods		(Grain)
1970	50.6	(6.3)	29.7	19.7	(12.3)
1975	57.3	(17.5)	26.2	16.5	(8.1)
1980	65.0	(25.3)	23.0	12.1	(5.7)
1985	55.9	(17.9)	35.5	8.5	(3.8)
1988	53.8	(7.1)	36.7	9.4	(3.2)

Source : Economic Planning Board, *Major Statistics of Korean Economy*, 1989.

Figure 3.3

Real Import Prices in Domestic Currency, Korea, 1971-1988

(1971=100)



Notes : PNI (import price of raw materials*(W/$)rate/GDP deflator)
PKI (import price of capital goods*(W/$)rate/GDP deflator)
PCI (import price of consumer goods*(W/$)rate/GDP deflator)

from 80.3% in 1970 to 90.6% in 1988. The continuous decline in the share of consumer goods reflects the reduction in the imported food grains. The value of imported producer goods increased sharply after the rise of import prices of these goods. On the other hand, the share of manufactured goods in the total exports has increased from 76% in 1970 to more than 90% in 1980s. This pattern of exports is just the reflection of the change in industrial structure towards manufacturing over the period. Figure 3.3 shows the fluctuations of the real import prices in domestic currency terms.

Because of the large share of trade in the current account and GNP, and especially the large share of imported inputs (including oil) in total imports, the external factors such as the terms-of-trade and world real interest rates have always been important variables to the Korean economy.

3.3 The Role of Government

For at least the past two or three decades, the main objective of government policies in Korea has been to achieve continuous economic growth with efficient

production of tradables. Given the abundant labor force, profitable investment opportunities and low level of national savings, the importation of foreign savings (i.e. borrowing) has played a very important role in economic growth. The resulting accumulation of external debt has induced the government to pursue a growth-cum-export promotion strategy, or the outward-oriented development strategy. Various policies served for this purpose. Monetary and fiscal policies played important roles in resource mobilization and allocation as part of the industrial strategy. Industrial and commercial policies were mainly directed to the promotion of exports. The liberal world trade regime and the accessibility to the international financial market have helped the Korean economy to pursue the outward-oriented development strategy.

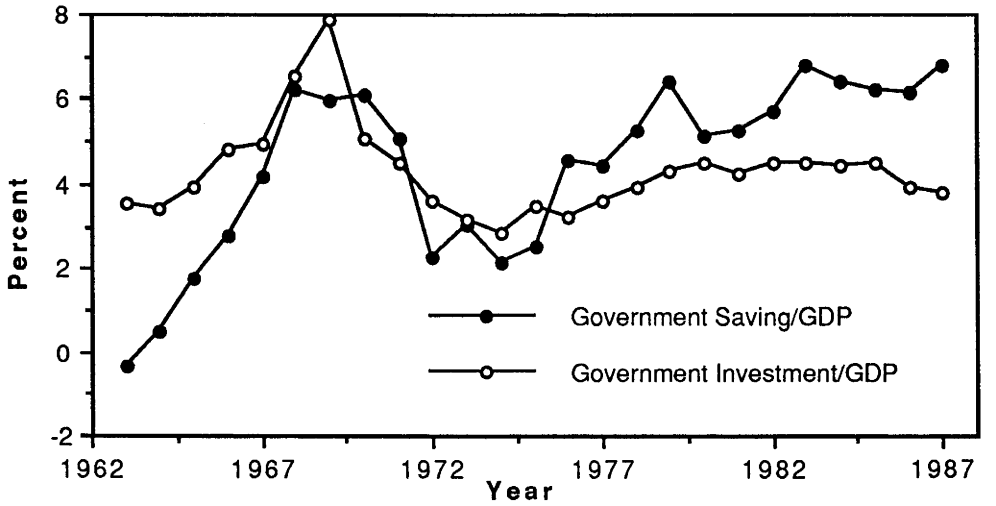
3.3.1 Fiscal and Monetary Policies

Fiscal policy in Korea has played an important role in activating growth and in enhancing domestic savings. As shown in Table 3.1, the rapid increase in the tax revenue (from 11.1% of GNP in 1960s to 17.7% of GNP in 1980s), which is attributable to the improvements in the tax system and the adoption of the value added tax

Figure 3.4

Government Saving and Investment, Korea 1963 ~ 1987

(percent of GDP)



(VAT) in the 1970s together with the constrained government expenditure, has contributed to the reduction of domestic investment-savings gap. Consequently, the government sector emerged as a net saver from 1970s as is illustrated in Table 3.2 and Figure 3.4. However, the budget of the consolidated public sector has recorded deficits controlled below 3% of GNP up to 1970s, and at 1.3% of GNP in 1980s on average (Table 3.1). This is because the government has borrowed more than is necessary to finance its own investment, in order to lend the funds to its "authorized" industries on a preferential basis.[2] Overall, the budget deficit was not the major component of the current account deficit.

On the other hand, monetary policy played mainly the role of credit allocation according to the priority of the industrial strategy reflected in the 5-year economic plans. The monetary policy had been rather expansionary up to the end of 1970s. However, this trend has been reversed since the early 1980s when the government adopted a stabilization package.

3.3.2 Exchange Rate and Trade Policies

Exchange rate policy has been oriented to maintaining the competitiveness of domestic goods in international markets. After the two oil-shocks, in 1974 and 1980, the nominal exchange rate was devalued 20% (Figure 3.5). During 1974 ~ 1979 when the nominal exchange rate was fixed to the U.S. dollar at 484 won, the real exchange rate was overvalued.[3] However, devaluation was afraided of due to its inflationary consequence. Except during this period, however, the real exchange rate was managed to maintain external competitiveness. Tax preferences and interest subsidies to the exporters played an important role in promoting exports, along the liberalization of import restrictions. Especially in the latter half of the 1970s, all these trade and industrial policies were directed towards the promotion of exports and new manufacturing industries [see Falvey and Gemmel (1989)].

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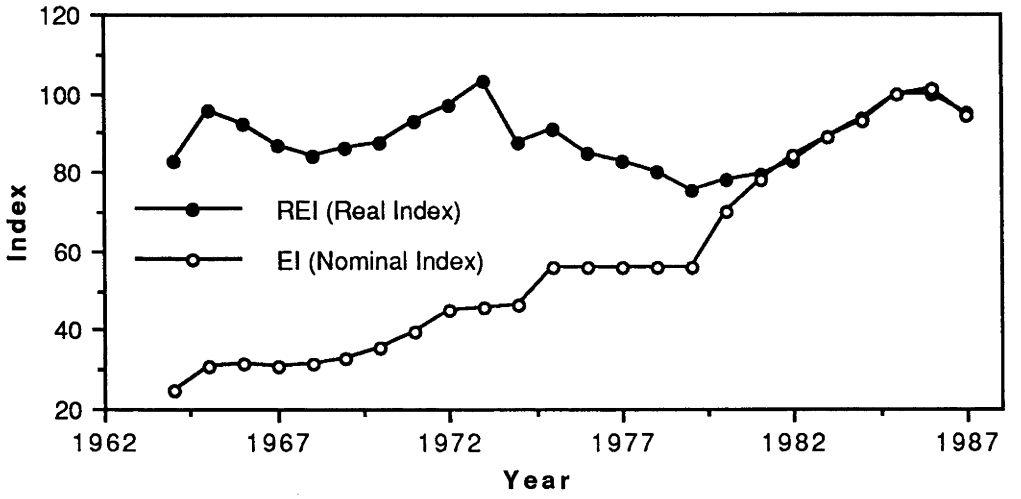
2 See Kim and Yun (1988), pp. 78.

3 The real exchange rate is defined as an index of the nominal exchange rate (W/$) relative to the purchasing power parity (PPP) exchange rate. That is , $(\frac{W}{\$})_{real,t+n} = \frac{(W/\$)_{t+n}}{(W/\$)_t} \frac{(P_{\$,t+n}/P_{\$,t})}{(P_{W,t+n}/P_{W,t})}$, where $P_\$$ and P_W represent the prices of foreign country and Korea.

Figure 3.5

Real Exchange Rate, Korea, 1964 ~ 1988

(1985=100)



Note : REI (real exchange rate index) = EI (nominal exchange rate index)*USWPI/KORWPI

3.4 External Shocks, Current Account, and Adjustment

3.4.1 Possible Adjustment Mechanism

According to the simple intertemporal analyses (see chapter 2), a permanent adverse shock will be matched by an equal fall in consumption, while a temporary shock will not. Similarly, only a permanent adverse shock will reduce investment. The outcome for the current account is a deterioration in the case of a temporary shock, but not in the case of a permanent shock. In the latter case, domestic adjustments will be made by reducing investment and sustaining and/or increasing savings.

The main concern of this section is to identify the actual relationships among the external shocks, the current account and macroeconomic adjustment in Korea. Empirical analyses of the external shocks and domestic responses can be divided into two groups : those that build a complete structural model of the economy, and those that decompose both shocks and responses into their principal elements. The former method will be discussed in later chapters, since it requires an explicit specification of the model. Although the latter method is rather crude, recently there have been several attempts of

using this method in explaining the experiences of the developing countries (for example, Bacha (1986), Balassa (1984,1986)).[4]

For the Korean case, Park (1986) and Collins and Park (1989) analyzed Korean experiences of the two oil-shock periods by this decomposition method. Although the latter study uses the KDI quarterly macroeconomic model to incorporate endogenous changes in behavior as a result of shocks, the principal components of decomposition are similar to those of the former one along the Bacha's (1986) decomposition. The components of both studies are world interest rates, import and export prices, import and export volumes, investment and domestic output. With these components of decomposition, we cannot show the role of the aggregate demand (consumption and investment). Moreover, we cannot force exports to be proportional to the world trade volume because of the limits on export supply especially in a small economy.

In order to capture the possible short-term adjustment mechanism, the following conceptual framework of Corden (1977) and Krugman (1988) is adopted. That is, the economy is assumed to produce tradables and non-tradables. Tradables consist of exportables and importables. Exportables, in turn, consist of actual exports as well as close substitutes for exports that are sold in domestic markets. Importables consist of actual imports as well as import competing goods. The domestic excess supply of exportables is then equal to actual exports, while the domestic excess demand for importables is actual imports.[5] When this economy attempts to adjust to an unfavorable external shock in the short run, it faces several choices. One way of adjustment is to reduce expenditure which can be attained by a reduction in investment and/or consumption (increase in saving) with the given output. Another way is to switch expenditure from foreign goods to domestic goods. Both of these adjustments can improve the current account by releasing more resources into exports and by reducing imports. The third and the most common way is to import foreign savings from the international capital markets. This mechanism can be easily incorporated into the decomposition analysis by modifying a few components. Imports are assumed to be

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[4] Also see *World Development*, vol. 14, no. 8 for several country studies.
[5] See "A Model of Balance of Payment Policy." in Corden (1977), pp. 7-18.

proportional to the absorption (consumption plus investment) rather than to the domestic output [see (A 3.2)]. Exports are assumed to be domestic excess supply of exportables rather than to be proportional to the world trade volume [see (A3.4)]. Then the resulting components of decomposition explicitly includes the role of aggregate demand (i.e. expenditure adjustment and expenditure switching) as well as the effects of external shocks. A more detailed description of the method data are attached in the appendix to this chapter.

The following sections show not only the degree of current account deterioration attributable to external shocks, but also that attributable to domestic short run adjustment characterized by expenditure reduction, expenditure switch, and foreign borrowing.

3.4.2 The First Oil-Shock (1973 ~ 75)

Table 3.5 shows the principal elements of the changes in the current account after the first oil-shock. The changes are differences between each year and the base year 1972/1973, as a ratio to the actual GDP. The current account deterioration as a ratio to the actual GDP was 7.8% in 1974 and 6.1% in 1975. However, this situation was reversed in 1976, showing that the current account deterioration was very short-lived in the period of the first oil-shock. The decomposition analysis shows that the main reasons of the current account deterioration in the 1974 ~ 75 period were external shocks, especially the terms-of-trade deterioration led by the sharp increase in the oil price. The increase in the oil price contributed to the increase in the current account deficit by 3.4% in 1974 and 4.0% in 1975, respectively. However, the price of exports also increased in 1974 and contributed a favorable effect on the current account of 2.3% in the same year. Altogether, the effects of terms-of-trade on the deterioration in the current account were 1.3% in 1974 and 4.4% in 1975. The effect of oil price increase was partly offset by the simultaneous increase in the price of exports in 1974, but not in 1975.

Domestic adjustment was not sufficient to offset the adverse effects of the terms-of-trade shock on the current account. Although the reduction in consumption exerted a

Table 3.5

Decomposition of Changes in the Current Account : 1974 ~ 1977
(changes are percent of actual GDP and relative to the base year 1972/73)[a]

	1974	1975	1976	1977
1. External Shocks	1.65	4.87	0.97	- 0.16
Terms of Trade Effect	1.32	4.36	0.75	- 0.53
Oil Import Price	3.36	4.04	3.38	3.02
Non-Oil Imports Price	0.21	- 0.21	- 5.88	- 9.28
Exports Price	- 2.25	0.53	3.25	5.73
Interest Rate Effect	0.33	0.51	0.22	0.37
2. Domestic Responses	5.68	0.49	- 4.00	- 2.87
Expenditure Reduction Effect	4.60	0.01	- 4.00	- 2.98
Consumption	- 3.11	- 3.96	- 8.18	- 10.96
Investment	7.71	3.97	4.18	7.98
Expenditure Switch Effect	1.08	0.48	- 0.00	0.12
Oil	0.64	0.01	- 0.52	- 0.45
Non-Oil	0.44	0.47	0.52	0.56
3. Other External Variables	0.32	0.60	1.15	- 0.05
Debt Accumulation	- 0.33	0.05	0.04	- 0.17
Other Investment Income	- 0.02	0.04	- 0.01	0.11
Employee's Compensation	0.31	0.37	0.44	0.54
Net Transfers	0.33	0.33	0.06	0.17
Changes in ERR[b]	0.03	- 0.20	0.62	- 0.70
4. Total (1+2+3)	7.66	5.96	- 1.88	- 3.08
5. Observed Deficit Increase	7.78	6.09	- 1.75	- 2.94

Notes : a A negative sign indicates an improvement in the current account (the decrease in the deficit).
b The statistical discrepancy item in the GDP identity.

favorable effect on the current account, it was dominated by the increase in investment. Gross investment and imports were not cut in spite of the oil shock. The overall expenditure reduction and switching to domestic goods did not occur because of the investment promotion led by the government, especially in the heavy and chemical industries during this period.

The response of consumption coincided with the theoretical implications, and the current account deterioration was dominated not by the decrease in saving, but by the increase in investment. This can be easily identified in Table 3.2 as well. For the most part, the Korean economy responded to the first oil-shock by increasing the current account deficit financed by foreign borrowing rather than through macroeconomic adjustment. In this sense, the Korean economy seems to have perceived the first oil shock as a temporary one. Since 1976 the terms-of-trade deterioration was reversed quickly and the current account improved quickly to a balance in 1977.

3.4.3 The Second Oil-Shock (1979 ~ 1981)

The adjustment experience during the second oil shock period was quite different from that of the first shock (Table 3.6). The deterioration in the current account as a ratio to the actual GDP was 4.2% in 1980 and 2.3% in 1981 compared to the base year 1978/1979, and thereafter the trend was reversed. Unlike the first oil-shock period, the deterioration of terms-of-trade was led not only by the oil price rise, but also by the increase in the prices of non-oil imports reflecting the global rise of the raw material prices. Additionally, the terms-of-trade deterioration was not reversed shortly after the shock, unlike the previous case.

The increase in oil price contributed to the increase in the current account deficit by 4.0% in 1980 and 4.8% in 1981. The increase in the price of non-oil imports also contributed to the increase in the deficit by 3.8% in 1980 and 4.4% in 1981. Since the rise in export prices exerted a favorable effect on the current account, the overall deterioration of the current account due to terms-of-trade effects amounted to 5.6% point in 1980 and 6.5% point in 1981. Moreover, the adverse effects of the external shock on the current account as a ratio to GDP were larger than those of the first oil-shock period, mainly because of the big decrease in the real GDP during the second oil-shock period.

Table 3.6

Decomposition of Changes in the Current Account : 1980 ~ 1983
(changes are percent of actual GDP and relative to the base year 1978/79)[a]

	1980	1981	1982	1983
1. External Shocks	6.26	7.40	5.74	5.14
Terms of Trade Effect	5.64	6.49	5.05	5.04
Oil Imports Price	4.01	4.81	4.37	3.35
Non-Oil Imports Price	3.80	4.39	2.20	2.78
Exports Price	- 2.17	- 2.72	- 1.52	- 1.08
Interest Rate Effect	0.62	0.92	0.70	0.10
2. Domestic Responses	- 2.85	- 5.65	- 7.97	- 8.54
Expenditure Reduction Effect	- 2.70	- 5.60	- 7.96	- 8.60
Consumption	2.51	- 0.03	- 1.01	- 3.28
Investment	- 5.21	- 5.57	- 6.95	- 5.31
Expenditure Switch Effect	- 0.15	- 0.05	- 0.02	0.06
Oil	- 0.15	- 0.04	0.00	0.09
Non-Oil	- 0.00	- 0.01	- 0.02	- 0.03
3. Other External Variables	0.80	0.49	1.65	1.19
Debt Accumulation	0.25	1.24	1.63	1.63
Other Investment Income	0.88	0.48	0.41	0.25
Employees' Compensation	0.11	- 0.02	- 0.02	- 0.09
Net Transfers	- 0.34	- 0.59	- 0.70	- 0.23
Changes in ERR[b]	- 0.11	- 0.62	0.33	- 0.38
4. Total (1+2+3)	4.20	2.24	- 0.58	- 2.20
5. Observed Deficit Increase	4.23	2.27	- 0.54	- 2.17

Notes : a A negative sign indicates an improvement in the current account (the decrease in the deficit).
b The statistical discrepancy item in the GDP identity.

Unlike the first oil-shock period, the domestic adjustment to the shock was quite extensive, especially in the investment behavior. The consumption contraction appeared with one year's lag and its magnitude was small. In contrast, the investment contraction effect was distinct. For the year 1980 ~ 1981, the current account improvement due to the investment contraction offset more than 122% of the adverse oil price effect on the

current account, and 89% of the adverse terms-of-trade effect on the current account. Overall, the expenditure reduction offset the increase in the deficit by 2.7% in 1980 and 5.6% in 1981. The effects of expenditure switching on the current account were also favorable, although the magnitude was very small. The overall response to the second oil-shock was a mix of macroeconomic adjustment and external financing. Korean economy seems to have perceived the second oil-shock partly temporarily and partly permanently.

3.4.4 Favorable Shock (1985 ~ 1987)

The current account position in Korea has been reversed from several decades of deficits to surpluses since 1986, mainly as a result of an improvement in the terms-of-trade and continuous export expansion. The decline in the oil price and foreign interest rates can be added to the factors behind this trend.

The decomposition analysis (Table 3.7) reveals the pattern of adjustment similar to the one observed after the first oil-shock, in the sense that the economy has run a current account surplus rather than macroeconomic adjustment. Although the terms-of-trade improvement contributed to the improvement in the current account by 2.4% in 1986 and 3.9% in 1987, expenditure increases or switching from domestic goods to imported goods did not occur. On the contrary, the real consumption ratio to the real GDP decreased in this period and exerted favorable effect on the current account. This is mainly caused by the sharp increase in the real GDP, and hence real saving. The experience of this period also suggests the economy took the favorable external conditions as temporary and ran a current account surplus rather than undergoing macroeconomic adjustment.

Table 3.7

Decomposition of Changes in the Current Account : 1986 ~ 1987
(changes are percent of actual GDP and relative to the base year 1984/85)[a]

	1986	1987
1. External Shocks	- 2.71	- 4.42
Terms of Trade Effect	- 2.38	- 3.90
Oil Imports Price	- 3.04	- 2.79
Non-Oil Imports Price	0.36	- 1.95
Exports Price	0.29	0.84
Interest Rate Effect	- 0.32	- 0.52
2. Domestic Responses	- 3.57	- 4.26
Expenditure Reduction Effect	- 3.55	- 4.25
Consumption	- 2.66	- 4.47
Investment	- 0.89	0.22
Expenditure Switch Effect	- 0.02	- 0.01
Oil	- 0.02	0.17
Non-Oil	0.00	- 0.19
3. Other External Variables	0.31	- 0.61
Debt Accumulation	- 0.01	- 0.75
Other Investment Income	- 0.15	- 0.17
Employees' Compensation	0.03	0.15
Net Transfers	0.13	0.37
Changes in ERR[b]	0.32	- 0.22
4. Total (1+2+3)	- 5.97	- 9.30
5. Observed Deficit Increase	- 5.96	- 9.29

Notes : a A negative sign indicates an improvement in the current account (the decrease in the deficit).
b The statistical discrepancy item in the GDP identity.

3.5 Discussion and Conclusions

The following remarks can be made from the brief overview of the Korean economy. Firstly, the economy is highly open with large shares of tradables in the manufacturing sector and trade in GNP. Furthermore, more than 90% of total imports

(in 1980s) are producer goods, that is, raw materials and capital goods. Therefore, the economy has been subject to and affected severely by the volatile external conditions such as terms-of-trade shocks. Secondly, the foreign saving played a crucial role in the early stage of capital accumulation and growth. In the meantime, the liberal world trade regime and the accessibility to the international financial market had beneficial effects on the economy. With the economic growth, the domestic saving has become to play more important role. Thirdly, the government also played an important role in allocating the limited resources through various policy instruments.

Regarding the response to the external shocks, the consumption dropped during both the first and the second oil-shock periods. The drop in consumption after the second oil shock realized with time lag and the magnitudes (as percent of GDP) were not so big as those of the first oil shock period. Investment also dropped quickly and significantly after the second oil shock, but not after the first oil shock. The increase in investment after the first oil shock is attributable to the investment boom led by the government. The current account recorded deficit during the both oil shock periods. This pattern of adjustment is not, of course, the pure outcome of the oil shocks only. It is the mixed outcome of various external shocks (oil price, non-oil price, interest rate, etc.) and policies implemented in response to those shocks during the periods. Although the simple decomposition analysis has provided some measures of the effects of external shocks, it still lacks several important channels such as that of the government policies.

Then, what can we say about the external economic shocks and the Korean experience of adjustment ? To what degree does each shock affect the important macroeconomic variables ? And moreover, is there any (stable) structural relationship between the shocks and the key macroeconomic variables from which we can predict the possible outcomes when the shocks occur again ? At this stage, there is not much to say about these questions.

From the next chapter on, this thesis will try to answer these questions by developing a formal framework. The specific features of the Korean economy mentioned above will be tried to incorporate in the framework.

Appendix to Chapter 3 : Decomposition Method

The changes in the current account are decomposed into different components from those of the previous studies to capture the role of external shocks and macroeconomic adjustment. In order to avoid confusion on the definitions of symbols, it is noted that all the symbols used in this appendix are strictly confined to this appendix, and independent of the symbols which will appear in later chapters.

Including the transactions in factor services and transfers, the current account deficit (CAD) can be expressed in domestic currency as follows :

(A3.1) $CAD \equiv M - X + NV - NR - NT \equiv M_1 + M_2 - X + NV - NR - NT$

where M is the imports of goods and nonfactor services, which can be divided into oil imports (M_1) and non-oil imports (M_2). X is the exports of goods and nonfactor services, NV is the net investment income payments to abroad, NR is the net compensation of employees from abroad, and NT is the net transfers from abroad. Imports can be expressed as the product of price and volume indices, and the import coefficient (m) is assumed to relate the import volume (M^*) to real domestic absorption (A^*) which is real total consumption (C^*) plus real gross domestic capital formation (I^*).

(A3.2) $M_i = P_i M_i^* = P_i m_i A^* = P_i m_i (C^* + I^*)$

where i = 1, 2 depending on the category of imports. Exports are also expressed as the product of price (P_x) and volume (X^*) indices. Unlike in Park (1986) and Collins and Park (1989), however, real exports are defined as the real excess supply of exportables according to the conceptual framework mentioned in the text. Thus :

(A3.3) $X = P_x X^*$

(A3.4) $X^* = Z^* + M_1^* + M_2^* - A^* - SD^*$, (from the real GDP identity)

Equation (A3.4) is an expression of real GDP identity, which identifies the excess supply of exportables as real GDP (Z^*) plus real imports minus absorption. SD^* is the statistical discrepancy (SD^*) in the real GDP identity.

The net investment income payments to abroad (NV) is divided into net interest payment to abroad rNF(t-1) and other investment income payments to abroad (ND), where r is the current dollar interest rate and NF(t-1) is the net foreign debt at the end of previous year.

(A3.5) $NV = rNF(t-1) + ND$

Substituting equations (A3.2) ~ (A3.5) into equation (A3.1), and dividing the result by GDP in current domestic prices ($Y = P_Y Z^*$), we get the equation (A3.6). P_Y is the implicit GDP deflator, and $\pi_1 = P_1/P_Y$, $\pi_2 = P_2/P_Y$, $\pi_X = P_X/P_Y$ are the relative prices of oil imports, non-oil imports, and exports to domestic output price, respectively.

(A3.6) $$CAD/Y = [(\pi_1 - \pi_X)m_1 + (\pi_2 - \pi_X)m_2](A^*/Z^*) - \pi_X(1 - A^*/Z^* - SD^*/Z^*) + r(NF(t-1)/Y) + (ND/Y) - (NR/Y) - (NT/Y)$$

Differentiating and rearranging (A3.6) leads to the final decomposition of changes in the current account deficit as (A3.7):

(A3.7) $$\begin{aligned} d(CAD/Y) = {} & + [m_1(A^*/Z^*)]d\pi_1 && \text{(oil import price effect)} \\ & + [m_2(A^*/Z^*)]d\pi_2 && \text{(non-oil import price effect)} \\ & - [(m_1 + m_2 - 1)(A^*/Z^*) + (1 - SD^*/Z^*)]d\pi_X && \text{(export price effect)} \\ & + [NF(t-1)/Y]dr && \text{(interest rate effect)} \\ & + [(\pi_1 - \pi_X)m_1 + (\pi_2 - \pi_X)m_2 + \pi_X]d(C^*/Z^*) \\ & && \text{(consumption adjustment effect)} \\ & + [(\pi_1 - \pi_X)m_1 + (\pi_2 - \pi_X)m_2 + \pi_X]d(I^*/Z^*) \\ & && \text{(investment adjustment effect)} \\ & + [(\pi_1 - \pi_X)(A^*/Z^*)]dm_1 && \text{(oil import replacement effect)} \end{aligned}$$

$+ [(\pi_2 - \pi_X)(A^*/Z^*)]dm_2$ (non-oil import replacement effect)

$+ [r]d(NF(t-1)/Y)$ (debt accumulation effect)

$+ d(ND/Y)$ (other investment income effect)

$- d(NR/Y)$ (workers' remittance effect)

$- d(NT/Y)$ (net transfer effect)

$+ [\pi_X]d(SD^*/Z^*)$ (changes in statistical discrepancy effect)

All the weights of the above decomposition (terms in square brackets) are the average of the base year and the compared year.

The following are the descriptions of the data used in the decomposition analysis. All the symbols are independent of those which will appear in the following theoretical chapters.

CAD = Current account deficit in current domestic currency prices (billion won).

Y = GDP in current domestic currency prices (billion won).

M_1 = Value of oil imports in current domestic currency prices (billion won).

M_2 = Value of imports of non-oil goods and services in current domestic currency prices (billion won).

X = Value of exports of goods and services in current domestic currency prices (billion won).

A^* = Real gross domestic absorption in 1980 domestic currency prices (1980 billion won).

C^* = Real final consumption expenditure in 1980 domestic currency prices (1980 billion won).

I^* = Real gross capital formation in 1980 domestic currency prices (1980 billion won).

Z^* = Real GDP in 1980 domestic currency prices (1980 billion won).

P_Y = Implicit GDP deflator with 1980 = 1.0, calculated as Y/Z^*.

M^* = Real value of imports in 1980 domestic currency prices (1980 billion won).

M_1^* = Real value of oil imports in 1980 domestic currency prices (1980 billion won), calculated as $M_1^* = (\$M_1/IOI)*1980$ Won/\$ rate, with $\$M_1$ for the value of oil

imports in current dollar, and IOI for the dollar import price index with 1980 = 1.0.

M_2^* = Real value of imports of non-oil goods and services in 1980 domestic currency prices (1980 billion won), calculated as $M^* - M_1^*$.

X^* = Real value of exports of goods and services in 1980 domestic currency prices (1980 billion won).

m_1 = M_1^*/A^*.

m_2 = M_2^*/A^*.

P_1 = Domestic currency price index of oil imports with 1980 = 1.0, calculated as M_1/M_1^*.

π_1 = P_1/P_Y.

P_2 = Domestic currency price index of imports of non-oil goods and services with 1980 =1.0, calculated as M_2/M_2^*.

π_2 = P_2/P_Y.

P_X = Domestic price index of exports with 1980 = 1.0, calculated as X/X^*.

π_X = P_X/P_Y.

NV = Value of net investment income payments to abroad in current domestic currency prices (billion won).

NF = Net foreign debt in current domestic currency prices, calculated by subtracting foreign assets from the total stock of foreign debt (billion won).

r = Dollar rate of interest, calculated implicitly as the ratio between interest payments in year t and debt outstanding in year t-1 [i.e. r = IP(t)/FD(t-1)].

ND = Other investment income to abroad in current domestic currency prices (billion won), calculated as NV - rNF(t-1).

NR = Net compensation of employees from the rest of the world in current domestic currency prices (billion won).

NT = Net current transfers from the rest of the world in current domestic currency prices (billion won).

SD^* = Value of statistical discrepancy in GDP identity in 1980 domestic currency prices (billion won).

CHAPTER 4

IMPORTED INPUT PRICE, THE CURRENT ACCOUNT AND MACROECONOMIC ADJUSTMENT : The Basic Model

4.1 Introduction

Analyses of the current account based on intertemporal optimization model have been very popular in analyzing the disturbances in an open economy. This is because macroeconomic adjustments to changes in the economic environment are conditioned by the intertemporal choices of the economic agents, and moreover, the current account dynamics is one of the important aspects of the intertemporal choices (see chapter 2).

This chapter presents an optimizing model of saving-investment and current account dynamics, and investigates the possible effects on the economy of external shocks such as increases in the price of an imported input. While we can view the current account as one of the following : the sum of the trade account and the service account, the difference between income and absorption, or the difference between saving and investment, it is convenient to exploit the saving minus investment identity in analyzing the current account dynamics within an intertemporal framework.

Since the current account dynamics is the outcome of saving and investment decisions, we need at least a model which incorporates not only the consumption/saving decisions but also the production/investment decisions simultaneously. One part of the existing literature [e.g. Obstfeld (1982a), Sachs (1982), Pitchford (1989)] is based on the consumption/saving behavior only, and hence the analysis of the current account ends up with a partial analysis in the sense that investment behavior is not incorporated. The other part incorporates investment behavior and can be divided into several categories. Sachs (1981), Razin (1984), and van Wijnbergen (1984b) are the examples of two period models which incorporate investment behavior. Abel and Blanchard (1983), Blanchard

(1983), and recently, Brock (1988) and Sen and Turnovsky (1989) are the examples of infinite-horizon optimizing models which incorporate investment behavior.

However, many infinite-horizon models also suffer the disadvantage that consumption dynamics are flat in the sense that consumption is constant at the initial level throughout the planning horizon. That is because the time preference rate is assumed to be equal to the constant real interest rate, in order to guarantee the existence of a steady-state equilibrium. Matsuyama (1987) provides an example of a model which incorporates investment behavior into the finite-horizon Blanchard (1985) framework and deals with the effects of an imported input price shock which is the focus of this chapter. Being a finite horizon model, it guarantees the existence of a stable steady-state for a small open economy even with a constant rate of time preference which is different from the constant world real interest rate.

This chapter provides an alternative possibility within the infinite-horizon optimizing framework of saving-investment by introducing a risk premium to the real cost of borrowing. The introduction of a risk premium is based on the fact that the world credit markets are not completely perfect for a small open developing economy. That is, the individual borrowing country faces an upward sloping supply schedule of foreign funds rather than a horizontal one. The rationale for this assumption is that increases in the level of debt increase the probability of default and hence drive the interest rate upward. The positive relationship between the level of indebtedness and the risk premium is confirmed in empirical analyses [e.g. Edwards (1986a)]. By introducing a risk premium to the real interest rate, the problem of flat consumption/saving dynamics can be avoided and more realistic results are obtained. The contributions and differences in the results from previous studies will be discussed throughout the analysis.

4.2 The Model

The Korean economy, as discussed in chapter 3, is a typical resource-poor small open economy. Its main characteristics can be summarized as follows :

(a) The economy is highly open with large shares of tradable manufacturing sector and trade.

(b) Most of the imports are producer goods which consist of intermediate inputs and capital goods.

(c) The liberalized world trade regime and access to the international credit markets were important to Korean trade and growth.

(d) The government played an important role in resource mobilization and allocation through various policies.

To begin with, the following simplifications are introduced in the model in order to capture the above characteristics.

(1) The economy produces only tradable goods which can be used for both consumption and investment.

(2) There is only one type of asset which can be traded internationally.

(3) The model is defined in real terms, i.e., there is no monetary sector in the economy.

(4) The economy consists of a fixed number of representative agent (consumer/producers).

(5) The agent has perfect foresight on the future exogenous variables.

The agent's decisions are determined by maximizing lifetime utility ($\tilde{U}$) subject to the intertemporal budget constraint. Lifetime utility is assumed to be additively separable in time with a constant rate of time preference (ρ). The instantaneous utility function (U) is assumed to be non-negative, increasing and strictly concave in private consumption (C), and also to be twice continuously differentiable.

$$(4.1)\quad \tilde{U} = \int_0^{\infty} U(C_t)e^{-\rho t}dt$$

where $U \in C^{(2)}$, $U'(C) > 0$, $U''(C) < 0$, $U'(0) = \infty$

The last condition, $U'(0) = \infty$, is postulated to avoid non-interior solutions to the agent's lifetime optimization problem. Then $\theta(C) = - U''(C)C/U'(C)$ denotes the elasticity of marginal utility or, in other words, the coefficient of relative risk aversion. The inverse of this coefficient, $1/\theta(C)$, is also called the agent's intertemporal elasticity of substitution in consumption.

Production (Q) of the tradable goods uses capital (K), labor (L), and imported intermediate input (N). $Q = Q(K,L,N)$ is a well behaved constant returns production function for gross output of the tradable goods. If we let the price of tradable output be unity as a numeraire, the relative price of imported input to the price of domestic output (π) is given. For simplicity, we assume that labor supply is inelastic and remains constant, which is normalized to be unity. The real wage is fully flexible to ensure the constant labor employment. Although the assumption of full employment with a flexible real wage is rather a restrictive assumption [1], we can, to begin with, focus on the adjustment mechanism which links the capital accumulation and the intermediate imported input use. The assumption of inelastic supply of labor will be relaxed in chapter 6. The gross output function which is increasing and strictly concave in capital and imported intermediate input is expressed as equation (4.2).

$$(4.2)\quad Q_t = Q(K_t, N_t, \bar{L})$$

where $Q_K > 0$, $Q_N > 0$, $Q_{KK} < 0$, $Q_{NN} < 0$

$$Q_{KK}Q_{NN} - Q_{KN}^2 > 0$$

The capital stock accumulates according to the following relationship (4.3), where I_t is gross investment and δ is the rate of depreciation of capital stock.

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[1] van Wijnbergen (1985b) incorporates explicitly the diequilibrium in labor and goods markets in two-period model, and shows the effects of oil price shocks on unemployment, investment and the current account.

(4.3) $\dot{K}_t = I_t - \delta K_t$, K_0 is given.

It is well known that one of the main drawbacks of the standard model is the assumption of the instantaneous adjustment in capital stock to equate the marginal product of capital with the real interest rate. In the real world, however, it is reasonable to assume that capital formation is accompanied by adjustment (or installation) costs.

The cost of installing physical capital is usually assumed to depend on the size of investment (I) relative to capital stock (K). Following the tradition [2] of introducing the adjustment costs associated with investment, we assume the adjustment costs per unit of investment will be an increasing and convex function of investment. Therefore, we introduce the adjustment costs per unit of net physical investment as $h(\frac{\dot{K}}{K})K$, where $h(\frac{\dot{K}}{K})$ is increasing and strictly convex in the relative size of net investment to capital stock, $(\frac{\dot{K}}{K})$.[3] Then, the total adjustment costs $h(\frac{\dot{K}}{K})K$ becomes increasing and strictly convex in net investment, $\dot{K}$. The total investment expenditure (TI) is, hence, the sum of gross investment and the adjustment costs :

(4.4) $TI_t = I_t + h(\frac{\dot{K}_t}{K_t})\, K_t$

where $h(\frac{\dot{K}}{K}) > 0$ for all $\frac{\dot{K}}{K} \neq 0$, $h(0) = 0$

$h'(\frac{\dot{K}}{K}) \gtreqless 0$ as $\frac{\dot{K}}{K} \gtreqless 0$, $h''(\frac{\dot{K}}{K}) > 0$ for all $\frac{\dot{K}}{K}$

It is noted from the properties of the h(·)-function that the installation costs become the scrapping costs when the net investment is negative.

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2 For example, see Lucas (1967), Gould (1968) and Treadway (1969). Alternative ways of introducing adjustment costs can be found in Uzawa (1969) and Hayashi (1982a).

3 If we assume the adjustment costs as a function of gross investment, $h(\frac{I}{K})K$, rather than net investment, the qualitative result does not change. However we can gain analytical simplicity from the latter specification.

In addition to the capital formation constraint (4.3), the agent also faces a flow constraint which relates the difference between income and expenditure to his accumulation of net foreign assets (or net debt). Another factor to note is that even a small developing economy usually faces an upward sloping supply schedule of foreign funds rather than horizontal one at the given world real interest rate. This is mainly because the interest rate charged includes a risk premium associated with potential default which is positively related to the level of debt outstanding. As discussed in the introduction, the positive effect of the level of indebtedness on the risk premium is confirmed in empirical cross-section analyses [e.g. Eaton and Gersovitz (1981), Edwards (1986a)]. In order to reflect the above relationship, we assume an interest repayment (debt service) or receipt function R(B) as in equation (4.5), according to the economy's net external position [where B (-B) is the net foreign assets (debt)].

$$(4.5)\quad R(B_t) = r(B_t)B_t \gtreqless 0 \quad \text{as } B_t \gtreqless 0$$

$$\text{where } r(B_t) > 0, \qquad r'(B_t) < 0,$$
$$R'(B_t) > 0, \quad R''(B_t) < 0 \quad \text{for all } B_t$$

This specification of interest repayments (or receipts) function (4.5) implies that each individual borrower imposes a negative externality on all other borrowers in the economy since additional borrowing drives up the interest cost for all.[4] From this formulation of the interest rate function, we can also easily analyze the case of constant real interest rate by setting $r'(B) = 0$.

Then, the representative agent's flow budget constraint always coincides with the current account equation (4.6).

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[4] On this point, see Bardhan (1967), Bruno (1976), Hamada (1969), McCabe and Sibley (1976), Obstfeld (1982b), and Pitchford (1970,1989). Among them, Obstfeld (1982b) and Pitchford (1989) are the examples of intertemporal optimizing models which analyze the effect of terms-of-trade deterioration on the current account with similar interest function as (4.5). However, their analyses are partial analyses in the sense that they do not consider the production/investment decision, but focus only on consumption/saving behavior.

$$(4.6)\quad \dot{B}_t = R(B_t) + Q(K_t,N_t,\bar{L}) - \pi N_t - C_t - I_t - h(\frac{\dot{K}_t}{K_t})\, K_t$$

where B_0 is given.

The consolidated flow budget constraint (4.6) shows that the current account is determined by the relative size of income $[R(B) + Q(K,N,\bar{L}) - \pi N]$ and absorption $[C + I + h(\frac{\dot{K}}{K})K]$, or saving $[R(B) + Q(K,N,\bar{L}) - \pi N - C\,]$ and investment $[I + h(\frac{\dot{K}}{K})K\,]$.

Finally, the following transversality conditions are imposed to ensure that both K and B remain bounded as time approaches infinity.

$$(4.7)\quad \lim_{t\to\infty} e^{-\rho t}\lambda_t \geq 0, \qquad \lim_{t\to\infty} e^{-\rho t}\lambda_t K_t = 0, \qquad \text{and}$$

$$\lim_{t\to\infty} e^{-\rho t}\psi_t \geq 0, \qquad \lim_{t\to\infty} e^{-\rho t}\psi_t B_t = 0$$

The optimizing problem of the agent is to choose $\{C_t,I_t,N_t\}$ which maximize the agent's utility (4.1) subject to the constraints (4.3), (4.6) and the transversality condition (4.7). The problem can be handled by the use of the current-value Hamiltonian, according to the Maximum Principle.

$$(4.8)\quad H = U(C_t) + \lambda_t\,[\,I_t - \delta K_t\,]$$
$$+ \psi_t\,[\,R(B_t) + Q(K_t,N_t,\bar{L}) - \pi N_t - C_t - I_t - h(\frac{\dot{K}_t}{K_t})\, K_t\,]$$

The co-state variables λ and ψ can be interpreted as the shadow values on the respective constraints ; λ is the shadow price of newly installed capital, and ψ is the shadow price of the final output (capital goods or consumer goods). Therefore, we can define a new variable $q = \lambda/\psi$, which is the ratio of the market value of new additional capital to its replacement cost, i.e., Tobin's q.

The first-order optimality conditions with respect to the decision variables are found by letting $\partial H/\partial C = \partial H/\partial I = \partial H/\partial N = 0$, $d(\lambda_t e^{-\rho t})/dt = -e^{-\rho t}(\partial H/\partial K)$ and $d(\psi_t e^{-\rho t})/dt = -e^{-\rho t}(\partial H/\partial B)$, respectively. From (4.8) we have :

(4.9a) $\psi_t = U'(C_t)$

(4.9b) $\lambda_t = \psi_t [1 + h'(\frac{\dot{K}_t}{K_t})]$

(4.9c) $\pi = Q_N(K_t, N_t, \bar{L})$, or $N_t = N(K_t, \bar{L}; \pi)$

(4.9d) $\dot{\lambda}_t = (\rho+\delta)\lambda_t - \psi_t [Q_K (K_t, N_t, \bar{L}) - h(\frac{\dot{K}_t}{K_t}) + (\frac{I_t}{K_t}) h'(\frac{\dot{K}_t}{K_t})]$

(4.9e) $\dot{\psi}_t = \psi_t [\rho - R'(B_t)]$

Equations (4.9a) ~ (4.9c) indicate the usual necessary conditions for static optimization. That is, consumption continues until the marginal utility of consumption equals the shadow price of consumption. Investment continues until the marginal cost equals the marginal benefit of the investment. Also the demand for the imported intermediate input continues until the marginal physical product of the input equals the given real price of the imported intermediate input. Equation (4.9d) shows the dynamic optimal condition for investment that the capital gain ($\dot{\lambda}_t$) is the difference between the required return ($(\rho+\delta)\lambda_t$), and the marginal rentals from additional unit of capital [the second term on the right-hand side of (4.9d)]. In other words, the condition states that the actual return (capital gain plus the marginal rentals) should equal the required return. Finally, the equation (4.9e) shows the dynamic optimal condition for consumption that consumption changes until the time preference rate equals the real interest rate.

Then, the sufficiency theorem (Proposition 8 in Arrow and Kurz (1970), pp. 49) states that any policy solution which satisfies the conditions (4.7) and (4.9) is optimal if the maximized Hamiltonian is concave in its state variables (K and B in our case), for given t and costate variables (λ_t and ψ_t in our case) which are non-negative. Kamien and Schwartz (1971) also show that, if the current-value Hamiltonian is concave both in its

state variables (K and B) and control variables (C, I, and N in our case), the maximized Hamiltonian is concave in its state variables. Therefore, the sufficiency condition can be applied by checking whether the current-value Hamiltonian is concave in the control and state variables. The concavity of the current-value Hamiltonian on the domain consisting of C, I, N, K, and B can easily be identified (see the appendix to this chapter).

Since the sufficient condition is satisfied in our case, we can obtain the system of dynamic equations from the necessary conditions (4.7) and (4.9) together with equations (4.3) and (4.6). First, using the relationship $q = \lambda/\psi$, and equations (4.3) and (4.9b), we can obtain the motion of capital accumulation as a function of Tobin's q and capital stock : [5]

$$(4.10) \quad \dot{K}_t = I_t - \delta K_t = x(q_t - 1)K_t$$

$$\text{where} \quad x(q_t - 1) \gtreqless 0 \quad \text{as} \quad q_t - 1 \gtreqless 0,$$

$$x'(q_t - 1) > 0 \quad \text{for all} \quad q_t - 1$$

The function $x(\cdot)$ is the inverse function of the monotonic function $h'(\cdot)$ defined in (4.4). Equation (4.10) shows that net investment (capital accumulation) is encouraged when capital is valued more highly in the market than its replacement cost ($q > 1$), and discouraged when its valuation is less than its replacement cost ($q < 1$).

Secondly, the path of optimal consumption is obtained from equations (4.9a) and (4.9e).

$$(4.11) \quad \dot{C}_t = \frac{-C_t}{\theta(C_t)}[\rho - R'(B_t)]$$

$$\text{where} \quad \theta(C_t) = \frac{-U''(C_t)C_t}{U'(C_t)}$$

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[5] Since Tobin's q can be expressed as $q = \lambda/\psi = 1 + h'(\frac{\dot{K}}{K})$ from (4.8b), $\frac{\dot{K}}{K}$ can also be expressed as the inverse function, x of the monotonic function, h' defined in (4.4). See Hayashi (1982a) for more details on the q-theory. The q-theory maintains that q contains important information about investment incentives that cannot be conveyed properly by traditional variables such as interest rates.

The relationship (4.11) shows that consumption changes until the time preference rate is equated with the marginal cost of borrowing. If we rearrange equation (4.11), we obtain another expression (4.11a) :

$$(4.11a)\quad R'(B_t) = \rho - \frac{U''(C_t)}{U'(C_t)}\dot{C}$$

If we assume the economy is a borrower for convenience, the term $R'(B_t)$ is of course the marginal (social) cost of borrowing from abroad. The right hand side of equation (4.11a) is the marginal rate of premium (in utility) which the individual consumer places on present consumption over future consumption. If consumption is constant, this premium rate is simply the individual's time preference rate ρ. But if consumption is changing over time, an additional term arises from the assumed concavity of the function $U(C_t)$. In the case of constant real interest rate, however, the R'(B) term in (4.11) will become r [$R'(B) = r(B) + r'(B)B = r$, since $r'(B) = 0$]. Hence, the consumption path should be flat from the beginning to guarantee the long run equilibrium where $\rho = r$.

Thirdly, equations (4.9d) and (4.9e) show the paths of shadow prices over time. Using these two equations together with (4.9b), (4.9c), (4.10), and the relationship $q = \lambda/\psi$, we can derive the behavior of Tobin's q over time :

$$(4.12)\quad \dot{q}_t = [R'(B_t) + \delta]q_t - [Q_K(K_t,N(K_t,\bar{L};\pi),\bar{L}) - h(\frac{\dot{K}_t}{K_t}) + (\frac{I_t}{K_t})\, h'(\frac{\dot{K}_t}{K_t})]$$

$$= [R'(B_t) + \delta]q_t - [Q_K(K_t,N(K_t,\bar{L};\pi),\bar{L}) - h(x(q_t-1)) + (q_t-1)\{x(q_t-1) + \delta\}]$$

Equation (4.12) can also be rearranged as follows :

$$(4.12a)\quad R'(B_t) = [\dot{q}_t + Q_K(K_t,N(K_t,\bar{L};\pi),\bar{L}) - h(x(q_t-1)) + (q_t-1)\{x(q_t-1) + \delta\}]/q_t - \delta$$

The right hand side of (4.12a) is the net marginal rentals (in utility) after allowing for both depreciation and adjustment cost. Again, if Tobin's q equals unity, this term is simply net marginal physical product of capital. If, again, we assume the economy is a

borrower, the agent (producer) equates this adjusted net marginal rentals to the (social) cost of borrowing, at the optimum. In the absence of a tax on foreign borrowing and lending, the representative atomistic consumer would equate the right hand side of (4.11a) to the private cost of borrowing, which is the market interest rate $r(B_t)$, rather than to the social cost of borrowing, $R'(B_t)$. Similarly, the representative atomistic producer would equate the net marginal rental after allowing for adjustment costs, to $r(B_t)$, rather than to $R'(B_t)$. Therefore, by setting up the model in this way, we are implicitly assuming that an optimal tax on foreign borrowing or lending has been imposed. This optimal tax must equal the excess of the marginal social cost of borrowing over the marginal private cost.

Finally, the path of assets/debt accumulation (4.6) can be rewritten using the relationships (4.9c), and (4.10) as follows :

$$(4.13)\quad \dot{B}_t = R(B_t) + Q(K_t,N(K_t,\bar{L};\pi),\bar{L}) - \pi N(K_t,\bar{L};\pi) - C_t$$
$$- x(q_t - 1)K_t - \delta K_t - h(x(q_t - 1))K_t$$
$$= R(B_t) + F(K_t,\bar{L};\pi) - C_t - x(q_t - 1)K_t - \delta K_t - h(x(q_t - 1))K_t$$

It is worthwhile to note that the second term (Q) and third term (πN) in the right-hand side of equation (4.13) constitute the real value-added (real GDP) function (F) since the two terms altogether imply the gross output net of the value of optimal use of imported intermediate input, given the relative price of imported input (π). That is, if we assume the optimal use of imported intermediate input in the production of gross output such that $\partial Q/\partial N = \pi$, the value-added output function can be defined as equation (4.14) which is used in the latter part of expression in equation (4.13).

$$(4.14)\quad F(K_t,\bar{L};\pi) = \max_{N_t} [Q(K_t,N_t,\bar{L}) - \pi N_t]$$
$$= Q(K_t,N(K_t,\bar{L};\pi),\bar{L}) - \pi N(K_t,\bar{L};\pi)$$

where $\pi = Q_N(K,N,\bar{L})$,

$$F_\pi = -N = -N(K,\bar{L};\pi)$$

$$F_K = Q_K(K,N(K,\bar{L};\pi),\bar{L}) > 0$$

$$F_{KK} = Q_{KK} + Q_{KN}N_K = [Q_{KK}Q_{NN} - Q_{KN}^2]/Q_{NN} < 0$$

Since the gross output function Q is assumed to be linearly homogeneous, the value-added function F is also linearly homogeneous in the primary factors L and K. Therefore, the Euler's Theorem holds for the real value-added (real GDP) function as (4.15) where w is the real wage in terms of output price.

(4.15) $F(K,\bar{L};\pi) = F_K K + w\bar{L}$

The dynamic system of the model economy comprises the four non-linear differential equations (4.10) ~ (4.13). The equilibrium path of the economy is obtained from solving this dynamic system simultaneously.

4.3 Steady-State and Dynamics

As shown in the previous section, this model is characterized by a system of four non-linear differential equations (4.10) ~ (4.13). Since the paths which converge to the steady-state satisfy the sufficient condition for optimality, we shall concentrate on the paths to long-run steady-state. The steady-state defined by $\dot{K}_t = \dot{C}_t = \dot{q}_t = \dot{B}_t = 0$ is characterized as follows. It is more convenient to consider the steady-state behavior first since the paths to the steady-state require the existence of the steady-state.

(4.16a) $q^* = 1$

(4.16b) $R'(B^*) = \rho$

(4.16c) $R'(B^*) = Q_K(K^*,N^*,\bar{L}) - \delta = F_K(K^*,\bar{L};\pi) - \delta$

$$(4.16d) \quad C^* = R(B^*) + Q(K^*,N^*,\bar{L}) - \pi N^* - \delta K^*$$
$$= R(B^*) + F(K^*,\bar{L};\pi) - \delta K^*$$

$$(4.16e) \quad \pi = Q_N(K^*N^*,\bar{L})$$

$$(4.16f) \quad w^* \bar{L} = F(K^*,\bar{L};\pi) - F_K(K^*,\bar{L};\pi)K^*$$

Equations (4.16) determine the unique values of q^*, B^*, K^*, C^*, N^*, and w^* simultaneously. The steady-state Tobin's q is unity as in equation (4.16a). The steady-state level of net foreign assets is determined by the time preference rate as in equation (4.16b). Equations (4.16c) and (4.16e) determine the steady-state values of the capital stock and the use of the imported intermediate input. Since the net investment is zero in the steady-state, the total investment expenditure is equal to the amount of capital depreciation. The steady-state consumption, consequently, is equal to net national product which is GNP minus capital depreciation $[R(B^*) + F(K^*,\bar{L};\pi) - \delta K^*]$ as in equation (4.16d). Another aspect worth noting is that equations (4.16c) and (4.16f) constitute a standard factor price frontier, from which the steady-state real wage (w^*) can be determined, given the relative price of the imported input (π).

Since we are interested in the path which converges to the long run steady-state, we linearize the system of equations (4.10) ~ (4.13) around the steady-state values of K^*, B^*, C^*, and $q^* = 1$, using the informations in (4.16).

$$(4.17) \quad \begin{bmatrix} \dot{K}_t \\ \dot{B}_t \\ \dot{C}_t \\ \dot{q}_t \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & a_1K^* \\ \rho & \rho & -1 & -a_1K^* \\ 0 & -a_2C^*/\theta^* & 0 & 0 \\ a_3 & -a_2 & 0 & \rho \end{bmatrix} \begin{bmatrix} K_t - K^* \\ B_t - B^* \\ C_t - C^* \\ q_t - 1 \end{bmatrix}$$

where $a_1 = x'(q^* - 1) = x'(0) > 0$

$a_2 = - R''(B^*) > 0$

$a_3 = - F_{KK} = - [Q_{KK} + Q_{KN}N_K] = - [Q_{KK}\, Q_{NN} - Q_{KN}^2] / Q_{NN} > 0$

$\rho = R'(B^*) = F_K - \delta = Q_K - \delta > 0$

$\theta^* = - U''(C^*)C^*/U'(C^*) > 0$

There are two stable (negative) eigenvalues corresponding to the two predetermined variables (K, B), and two unstable (positive) eigenvalues corresponding to the two non-predetermined jump variables (C, q). This proves that, in the neighborhood of the long run steady-state, there exists a unique convergent saddle path to the steady-state. The eigenvalues of the transition matrix in (4.17) are :

$$(4.18) \quad \gamma_1 = \frac{\rho - \sqrt{\rho^2 + 2(P - D)}}{2} < 0 \qquad \gamma_2 = \frac{\rho - \sqrt{\rho^2 + 2(P + D)}}{2} < 0$$

$$\gamma_3 = \frac{\rho + \sqrt{\rho^2 + 2(P - D)}}{2} > 0 \qquad \gamma_4 = \frac{\rho + \sqrt{\rho^2 + 2(P + D)}}{2} > 0$$

where $P = a_2C^*/\theta^* + a_1K^*(a_2 + a_3) > 0$

$$D = \sqrt{P^2 - 4a_1a_2a_3C^*K^*/\theta^*}$$

$$= \sqrt{[a_2C^*/\theta^* + a_1K^*(a_2 - a_3)]^2 + 4a_1^2a_2a_3K^{*2}} > 0$$

$P - D > 0$

$|\gamma_1| < |\gamma_2|, \quad \gamma_3 < \gamma_4$

Since the number of negative eigenvalues equals the number of predetermined variables, and the number of positive eigenvalues equals the number of jump variables, we can directly employ the solution method for the continuous perfect foresight saddle path problem described in Buiter (1984). Using the method described in the appendix, the saddle path to the long-run steady-state is given as (4.19) :

$$(4.19a)\quad K_t - K^* = \frac{1}{D}[(Z_1e^{\gamma_2 t} - Z_2e^{\gamma_1 t})(K_0 - K^*) + a_1a_2K^*(e^{\gamma_1 t} - e^{\gamma_2 t})(B_0 - B^*)]$$

$$(4.19b)\quad B_t - B^* = \frac{1}{a_1a_2K^*D}[Z_1Z_2(e^{\gamma_2 t} - e^{\gamma_1 t})(K_0 - K^*) + a_1a_2K^*(Z_1e^{\gamma_1 t} - Z_2e^{\gamma_2 t})(B_0 - B^*)]$$

$$(4.19c)\quad C_t - C^* = \frac{1}{\theta^*\gamma_1\gamma_2a_1K^*D}[C^*Z_1Z_2(\gamma_2e^{\gamma_1 t} - \gamma_1e^{\gamma_2 t})(K_0 - K^*) + a_1a_2C^*K^*(Z_2\gamma_1e^{\gamma_2 t} - Z_1\gamma_2e^{\gamma_1 t})(B_0 - B^*)]$$

$$(4.19d)\quad q_t - 1 = \frac{1}{a_1K^*D}[(Z_1\gamma_2e^{\gamma_2 t} - Z_2\gamma_1e^{\gamma_1 t})(K_0 - K^*) + a_1a_2K^*(\gamma_1e^{\gamma_1 t} - \gamma_2e^{\gamma_2 t})(B_0 - B^*)]$$

$$(4.19e)\quad \dot{B}_t = \frac{1}{a_1a_2K^*D}[Z_1Z_2(\gamma_2e^{\gamma_2 t} - \gamma_1e^{\gamma_1 t})(K_0 - K^*) + a_1a_2K^*(Z_1\gamma_1e^{\gamma_1 t} - Z_2\gamma_2e^{\gamma_2 t})(B_0 - B^*)]$$

where K_0 and B_0 are the capital stock and the net foreign assets at time zero, respectively. $Z_1 = a_1a_3K^* + \gamma_1\gamma_3 > 0$, and $Z_2 = a_1a_3K^* + \gamma_2\gamma_4 < 0$ are shown in the appendix. The current account path (4.19e) is derived by differentiating the foreign assets path (4.19b) with respect to time. It should be noted that the saddle path to the long run steady-state is governed by the state variables, K and B, as well as the stable eigenvalues, γ_1 and γ_2. In other words, the time path of the economy to the long run steady-state is affected by the difference between the steady-state level and initial level of state variables under the perfect foresight assumption. Additionally the speed of adjustment of the economy is affected by the absolute and relative size of the stable eigenvalues.

4.4 The Effects of External Disturbances

4.4.1 Long Run Effects of Permanent Increase in π

Suppose that there is an unanticipated permanent increase in the price of imported intermediate input at time t = 0. In order to examine the optimal responses to external disturbances, it is assumed that the economy is in the steady-state initially. The initial steady-state is denoted by subscript 0, and the new steady-state by superscript *. It is

convenient to begin with a consideration of the long-run equilibrium effects of external disturbances, since the adjustment of the economy is determined in part by the expectations of long run steady-state because of the perfect foresight assumption.

From the long run steady-state relationship (4.16), it is clear that changes resulting from the increase in the imported input price (π) occur only in equations (4.16c), (4.16d), (4.16e), and (4.16f). The long run steady-state values of B^* and $q^* = 1$ are determined independently of the level of the imported input price, which is evident from equations (4.16a) and (4.16b).

The long run responses of the capital stock, consumption, imported input use, and real wage to an unanticipated permanent increase in π can be obtained by differentiating equations (4.16) and solving for the endogenous variables :

(4.20a) $dq = q^* - q_0 = 0$

(4.20b) $dB = B^* - B_0 = 0$

(4.20c) $dK = K^* - K_0 = \frac{1}{a_3}(\frac{Q_{KN}}{Q_{NN}})d\pi < 0$

(4.20d) $dC = C^* - C_0 = \rho dK - N^* d\pi = [\frac{\rho}{a_3}(\frac{Q_{KN}}{Q_{NN}}) - N^*]d\pi < 0$

(4.20e) $dN = N^* - N_0 = -\frac{1}{a_3}(\frac{Q_{KK}}{Q_{NN}})d\pi < 0$

(4.20f) $dw = w^* - w_0 = -\frac{1}{\bar{L}}N^* d\pi < 0$

Equation (4.20c) shows that, in the long run, the capital stock falls in response to the permanent increase in the price of imported intermediate input under the assumption that capital and imported intermediate input are cooperative factors ($Q_{KN} > 0$). Naturally the use of imported intermediate input falls in the long run in response to its own price increase as shown in equation (4.20e). Since the real wage is assumed to adjust flexibly to ensure the constant level of employment ($\bar{L}$) in our model economy, it also falls unambiguously in the long run as shown in equation (4.20f). Reflecting the long run fall

in capital input and real wage income, the consumption falls as well. The magnitude of the long run fall in consumption coincides with the sum of the change in net national product caused by the decrease in capital stock (ρdK) and the change in the total real wage income ($dw\bar{L} = - N^* d\pi$). This is shown in equations (4.20d) and (4.20f).

Finally, equations (4.20a) and (4.20b) show that the Tobin's q and net foreign assets might be changed during the transitional period, but ultimately return to their initial steady-state values. Therefore, there are no long run effects of the increase in π on the Tobin's q and net foreign assets.

4.4.2 Transitional Effects of Permanent Increase in π

The transitional time path of the system to a new long run steady-state following an unanticipated permanent increase in the price of imported input can be obtained by using equations (4.19) and (4.20). The solution for the transitional path results from plugging (4.20b) and (4.20c) into equations (4.19), since the saddle path to the steady-state is expressed by only K, B, and other parameters including the stable eigenvalues. Hence, the transitional dynamics becomes (4.21) :

$$\text{(4.21a)} \quad K_t - K^* = -\left(\frac{1}{D}\right)(Z_1 e^{\gamma_2 t} - Z_2 e^{\gamma_1 t})\left(\frac{Q_{KN}}{a_3 Q_{NN}}\right)d\pi$$

$$\text{(4.21b)} \quad B_t - B^* = -\left(\frac{Z_1 Z_2}{a_1 a_2 K^* D}\right)(e^{\gamma_2 t} - e^{\gamma_1 t})\left(\frac{Q_{KN}}{a_3 Q_{NN}}\right)d\pi$$

$$\text{(4.21c)} \quad C_t - C^* = -\left(\frac{C^* Z_1 Z_2}{\theta^* \gamma_1 \gamma_2 a_1 K^* D}\right)(\gamma_2 e^{\gamma_1 t} - \gamma_1 e^{\gamma_2 t})\left(\frac{Q_{KN}}{a_3 Q_{NN}}\right)d\pi$$

$$\text{(4.21d)} \quad q_t - 1 = -\left(\frac{1}{a_1 K^* D}\right)(Z_1 \gamma_2 e^{\gamma_2 t} - Z_2 \gamma_1 e^{\gamma_1 t})\left(\frac{Q_{KN}}{a_3 Q_{NN}}\right)d\pi$$

$$\text{(4.21e)} \quad \dot{B}_t = -\left(\frac{Z_1 Z_2}{a_1 a_2 K^* D}\right)(\gamma_2 e^{\gamma_2 t} - \gamma_1 e^{\gamma_1 t})\left(\frac{Q_{KN}}{a_3 Q_{NN}}\right)d\pi$$

where $D, Z_1, a_1, a_2, a_3, \theta^*, C^*, K^*, Q_{KN} > 0$, $Z_2, \gamma_1, \gamma_2, Q_{NN} < 0$, and $|\gamma_1| < |\gamma_2|$. If the appropriate numbers satisfying the conditions for sign and relative size are assigned to the above eigenvalues and parameters, the motion of the system (4.21) can be conveniently traced in Figure 4.1.

At time zero when the permanent increase in π occurs, the Tobin's q drops by the amount $[(Z_1\gamma_2 - Z_2\gamma_1)/a_1K^*D](Q_{KN}/a_3Q_{NN})d\pi$, giving the signal to reduce investment. As time evolves the Tobin's q starts to increase until it reaches the initial steady-state value, unity [see equation (4.21d)]. Until the economy arrives at the point q = 1, optimal capital stock decreases continuously from K_0 to K^*, since q is less than unity during the transitional adjustment periods [see equation (4.21a)]. The total amount of the decrease in the capital stock is given in (4.20c). Although the Tobin's q drops discontinuously at time zero, the capital stock does not drop discontinuously but starts to decrease continuously from the beginning.

Consumption also falls reflecting the fall in the net income component of wealth caused by both the capital loss and the increased imports bill of intermediate inputs. At time zero consumption drops by the amount $[(\gamma_1 - \gamma_2)\gamma_3\gamma_4/D - \rho]dK + Nd\pi$, which is smaller than the long run drop in consumption.[6] As time evolves, consumption declines further until it reaches the new steady-state level C^*.

The impact effect on the current account is a surplus immediately after the unanticipated permanent increase in π, reflecting the quick drop in consumption. As time evolves, however, income starts to decline with disinvestment. The current account turns into deficit when the decrease in saving caused by the continuous decline in income exceeds the decrease in investment. The time when the current account turns into a deficit depends on the relative size of the stable eigenvalues, γ_1 and γ_2 $[t = \frac{1}{\gamma_1 - \gamma_2} ln (\frac{\gamma_2}{\gamma_1})]$.

Shortly after the initial surplus, therefore, the current account turns into deficit during the remaining transitional adjustment period until the economy reaches the new steady-state.[7] This result reflects the larger decrease in saving relative to the decrease in investment during the second stage of adjustment. Reflecting the position of the current

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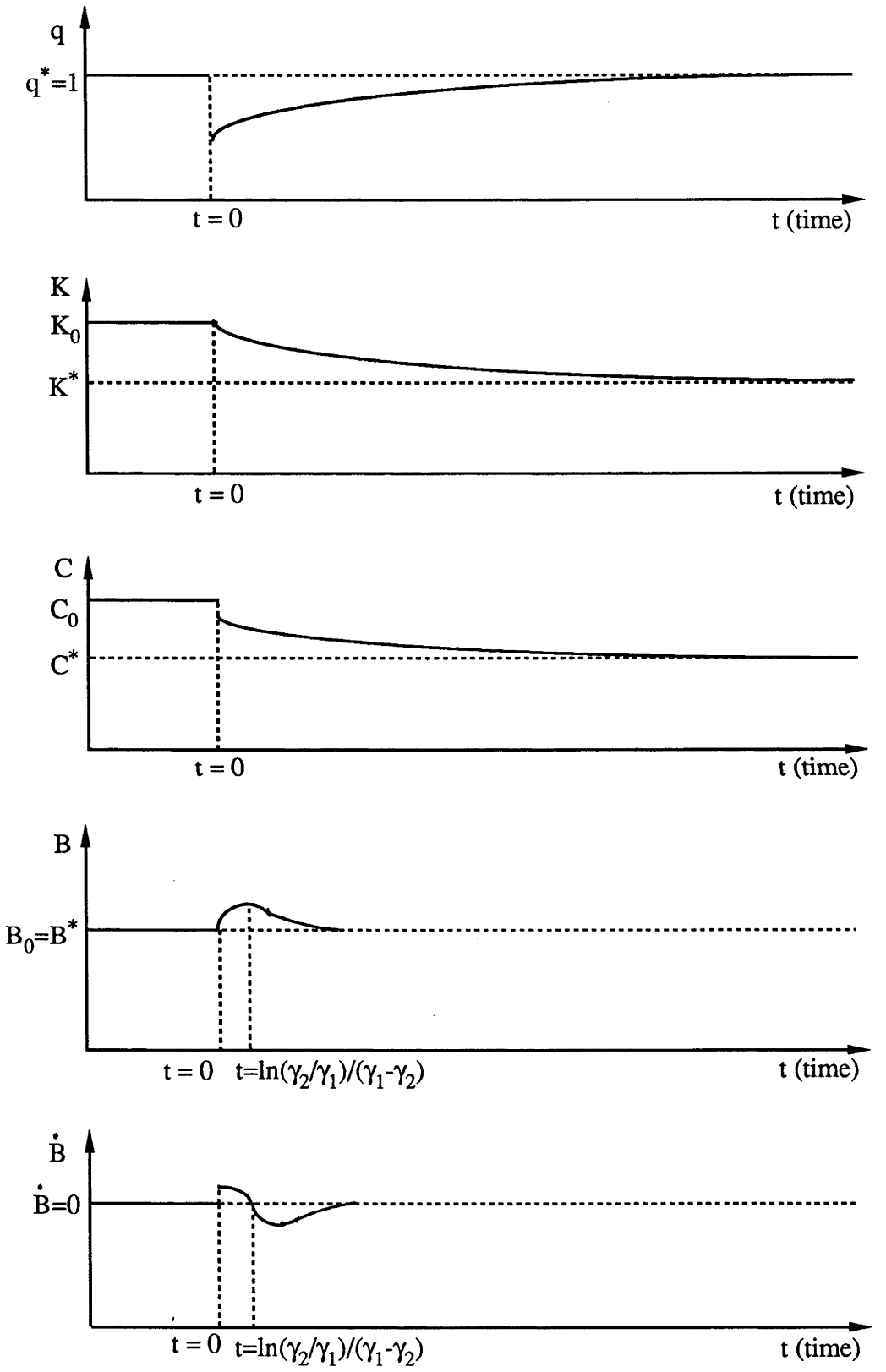
6 The initial drop in consumption can be obtained by subtracting $C_0 - C^* > 0$ in (4.21c) from the long run drop in consumption $-dC = C_0 - C^* = -\rho dK + Nd\pi > 0$ in (4.20d), since $C_t - C^*$ is positive for all t in (4.21c).

7 If we assume that the capital and imported intermediate input are non-cooperative ($Q_{KN} < 0$), the result is reversed. For the Korean case, however, it will be shown in chapter 6 that the two factors are cooperative ($Q_{KN} > 0$).

Figure 4.1

The Effects of an Unanticipated, Permanent Increase in π



account, the net foreign assets (or debt) holding rises (falls) while the current account is in surplus, and then falls (rises) to return to its initial steady-state value while the current account is in deficit. This pattern of current account response shows a significant contrast to the existing optimization theory which yields an unambiguous surplus [Obstfeld (1982a)], surplus or balance [Pitchford (1989)], or ambiguous result [Svensson and Razin (1983), Matsuyama (1987)]. Because of the interest rate function associated with the risk premium, the economy behaves as if it had a certain level of net foreign assets or debt target to maintain.

Therefore, an exogenous economic shock exerts long-run effects on non-human wealth, but not on net foreign assets unless the agent's preference structure is changed. Given the preference structure with a constant time preference rate, the effects of an imported input price shock on the economy is dominated by its long-run effect on the capital stock. This wealth effect differs significantly from Matsuyama's (1987) where the wealth effect occurs through the changes in net foreign assets rather than the capital stock. The channel through which an external shock affects the current account is also different : being a finite-horizon model, saving decision depends on the agent's human wealth and investment decision depends on the agent's portfolio substitution effect in Matsuyama (1987) ; in the case of Sen and Turnovsky (1989), the current account is affected only by the investment decision regardless of whether it is driven by wealth effect or substitution effect. In our case, however, the saving, investment and current account decisions are dominated by the wealth effect. Due to the different speed of adjustments in consumption and investment, the current account shows hump-shape responses, and moreover has a turning point rather than a monotonic surplus or deficit.

4.5 Conclusions

This chapter has analyzed the effects of an increase in the price of an imported input on a small economy using a simple intertemporal optimizing framework. In parallel with several models which analyze the current account adjustment based on intertemporal optimizing framework, this chapter has attempted to provide an alternative infinite-

horizon optimizing framework of saving, investment, and the current account. The introduction of a risk premium to the real interest rate allows us to analyze the consumption/savings dynamics as well as production/investment dynamics. An unanticipated permanent increase in the price of imported intermediate input results in long-run decreases in the capital stock, consumption, the real wage, and intermediate input use. When the imported input price rises, consumption falls immediately reflecting the fall in real income (value-added output) and continues to fall until it reaches a lower level at the new equilibrium. The capital stock and the use of imported input in production also fall, and hence income falls. The current account responds with a surplus immediately after the shock, but turns into deficit during the remaining adjustment period. The speed of adjustment and the time when the current account turns into a deficit depends on the relative size of the stable eigenvalues of the system.

These results, however, should be interpreted with caution since some of the underlying assumptions are restrictive. One strong assumption is the absence of an adjustment mechanism of labor employment. Although the real sector of the economy is the main interest of this chapter, the lack of price adjustment mechanism is another omission. The effects of an external shock will be observed not only in the real sector of the economy but also in the monetary sector. The world-wide stagflation after the second oil-shock is one example of this.

Appendix to Chapter 4

Sufficient Condition for Optimum

According to the sufficiency theorem in optimal control theory [Arrow and Kurz (1970), Kamien and Schwartz (1971)], any policy solution which satisfies the necessary conditions (4.9) and transversality conditions (4.7) is optimal if the maximized Hamiltonian is concave in the state variables (K and B). The concavity of the maximized Hamiltonian in the state variables is satisfied if the current-value Hamiltonian is concave in both control variables (C, I, and N) and state variables.[8] Therefore it is sufficient to check the concavity of the current-value Hamiltonian on the domain which consists of the control and state variables of the problem. For given non-negative λ and ψ, the Hessian determinant ($|H|$) of the current-value Hamiltonian, H(C, I, N, K, B), and the principal minors, $|H_i|$ (i = 1, ..., 5) are given in (A4.1) :

$$\text{(A4.1)} \quad |H| = \begin{vmatrix} U_{CC} & 0 & 0 & 0 & 0 \\ 0 & -\frac{\psi}{K}h''(\frac{\dot{K}}{K}) & 0 & \psi\frac{I}{K^2}h''(\frac{\dot{K}}{K}) & 0 \\ 0 & 0 & \psi Q_{NN} & \psi Q_{NK} & 0 \\ 0 & \psi\frac{I}{K^2}h''(\frac{\dot{K}}{K}) & \psi Q_{KN} & \psi[Q_{KK} - \frac{I^2}{K^3}h''(\frac{\dot{K}}{K})] & 0 \\ 0 & 0 & 0 & 0 & \psi R''(B) \end{vmatrix}$$

where $|H_1| = U_{CC} < 0$

$$|H_2| = -U_{CC}\frac{\psi}{K}h''(\frac{\dot{K}}{K}) > 0$$

$$|H_3| = -U_{CC}Q_{NN}\frac{\psi^2}{K}h''(\frac{\dot{K}}{K}) < 0$$

$$|H_4| = -U_{CC}\frac{\psi^3}{K}h''(\frac{\dot{K}}{K})(Q_{KK}Q_{NN} - Q_{KN}^2) > 0$$

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8 See the lemma in Kamien and Schwartz (1971), pp. 211.

$$|H_5| = -U_{CC}R''(B)\frac{\psi^4}{K}h''(\frac{\dot{K}}{K})(Q_{KK}Q_{NN} - Q_{KN}^2) < 0$$

The alternating signs in the principal minors obtained from the Hessian determinant shows that the current-value Hamiltonian is concave on the domain. Therefore, the solution which satisfies the necessary and transversality conditions is optimal.

Solution for the Unique Saddle Path

Using the solution method for the continuous time perfect foresight model described in Buiter (1984) and Murphy (1988), we can rewrite the linearized system (4.17) as follows :

$$\text{(A4.2)} \quad \begin{bmatrix} \dot{X}_1(t) \\ \dot{X}_2(t) \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} X_1(t) - X_1^* \\ X_2(t) - X_2^* \end{bmatrix}$$

where $X_1 = [K\ B]'$ is the vector of predetermined variables, $X_2 = [C\ q]'$ is the vector of non-predetermined variables, and A is the coefficient (transition) matrix. The matrix A can be diagonalized as follows :

$$\text{(A4.3)} \quad A = V\Gamma V^{-1}, \qquad V = \begin{bmatrix} V_{11} & V_{12} \\ V_{21} & V_{22} \end{bmatrix}, \qquad \Gamma = \begin{bmatrix} \Gamma_1 & 0 \\ 0 & \Gamma_2 \end{bmatrix}$$

where Γ_1 and Γ_2 are diagonal matrices with the stable and unstable eigenvalues of matrix A, respectively, and V is a conformable matrix with the associated eigenvectors of matrix A as columns.

The eigenvalues of matrix A can be obtained by solving the characteristic equation of A, $A(\gamma) = |A - \gamma I| = \gamma^2(\gamma-\rho)^2 - [\frac{a_2C^*}{\theta^*} + a_1K^*(a_2+a_3)]\gamma(\gamma-\rho) + \frac{a_1a_2a_3C^*K^*}{\theta^*} = 0.$

There are two negative eigenvalues (γ_1,γ_2) and two positive eigenvalues (γ_3,γ_4) as in equation (4.18) in the text. Hence, the matrix Γ is expressed as,

$$\text{(A4.4)}\quad \Gamma = \begin{bmatrix} \frac{\rho-\sqrt{\rho^2+2(P-D)}}{2} & 0 & 0 & 0 \\ 0 & \frac{\rho-\sqrt{\rho^2+2(P+D)}}{2} & 0 & 0 \\ 0 & 0 & \frac{\rho+\sqrt{\rho^2+2(P-D)}}{2} & 0 \\ 0 & 0 & 0 & \frac{\rho+\sqrt{\rho^2+2(P+D)}}{2} \end{bmatrix}$$

where $P = a_2C^*/\theta^* + a_1K^*(a_2 + a_3) > 0$

$$D = \sqrt{P^2 - 4a_1a_2a_3C^*K^*/\theta^*}$$

$$= \sqrt{[a_2C^*/\theta^* + a_1K^*(a_2 - a_3)]^2 + 4a_1^2a_2a_3K^{*2}} \quad > 0$$

$$P - D > 0, \quad |\gamma_1| < |\gamma_2|, \quad \gamma_3 < \gamma_4$$

The column eigenvectors V_i (i = 1,2,3,4) associated with the eigenvalues γ_i (i = 1,2,3,4) of matrix A can be obtained by solving the matrix equation $[A - \gamma_i I]V_i = 0$ for V_i (i = 1,2,3,4) with the condition of normalization. The resulting matrix $V = [V_1\ V_2\ V_3\ V_4]$ is expressed as follows.

$$\text{(A4.5)}\quad V = \begin{bmatrix} \frac{-\theta^*a_1a_2K^*\gamma_1}{\sqrt{A_1}} & \frac{-\theta^*a_1a_2K^*\gamma_2}{\sqrt{A_2}} & \frac{\theta^*a_1a_2K^*\gamma_3}{\sqrt{A_3}} & \frac{\theta^*a_1a_2K^*\gamma_4}{\sqrt{A_4}} \\ \frac{-\theta^*Z_1\gamma_1}{\sqrt{A_1}} & \frac{-\theta^*Z_2\gamma_2}{\sqrt{A_2}} & \frac{\theta^*Z_1\gamma_3}{\sqrt{A_3}} & \frac{\theta^*Z_2\gamma_4}{\sqrt{A_4}} \\ \frac{a_2C^*Z_1}{\sqrt{A_1}} & \frac{a_2C^*Z_2}{\sqrt{A_2}} & \frac{-a_2C^*Z_1}{\sqrt{A_3}} & \frac{-a_2C^*Z_2}{\sqrt{A_4}} \\ \frac{-\theta^*a_2\gamma_1^2}{\sqrt{A_1}} & \frac{-\theta^*a_2\gamma_2^2}{\sqrt{A_2}} & \frac{\theta^*a_2\gamma_3^2}{\sqrt{A_3}} & \frac{\theta^*a_2\gamma_4^2}{\sqrt{A_4}} \end{bmatrix}$$

where $A_1 = Z_1^2(\theta^{*2}\gamma_1^2 + a_2^2C^{*2}) + \gamma_1^2\theta^{*2}a_2^2(\gamma_1^2 + a_1^2K^{*2}) > 0$

$$A_2 = Z_2^2(\theta^{*2}\gamma_2^2 + a_2^2C^{*2}) + \gamma_2^2\theta^{*2}a_2^2(\gamma_2^2 + a_1^2K^{*2}) > 0$$

$$A_3 = Z_1^2(\theta^{*2}\gamma_3^2 + a_2^2C^{*2}) + \gamma_3^2\theta^{*2}a_2^2(\gamma_3^2 + a_1^2K^{*2}) > 0$$

$$A_4 = Z_2^2(\theta^{*2}\gamma_4^2 + a_2^2C^{*2}) + \gamma_4^2\theta^{*2}a_2^2(\gamma_4^2 + a_1^2K^{*2}) > 0$$

$$Z_1 = a_1a_3K^* + \gamma_1\gamma_3$$

$$= \frac{-[a_2C^*/\theta^*+a_1K^*(a_2-a_3)]+\sqrt{[a_2C^*/\theta^*+a_1K^*(a_2-a_3)]^2+4a_1^2a_2a_3K^{*2}}}{2} > 0$$

$$Z_2 = a_1a_3K^* + \gamma_2\gamma_4$$

$$= \frac{-[a_2C^*/\theta^*+a_1K^*(a_2-a_3)]-\sqrt{[a_2C^*/\theta^*+a_1K^*(a_2-a_3)]^2+4a_1^2a_2a_3K^{*2}}}{2} < 0$$

Finally, given that Γ_1 is a diagonal matrix [9], the exponential matrix $e^{\Gamma_1 t}$ is defined as follows :

$$\text{(A4.6)} \quad e^{\Gamma_1 t} = \begin{bmatrix} e^{\gamma_1 t} & 0 \\ 0 & e^{\gamma_2 t} \end{bmatrix}$$

Then, the solution for the unique saddle path is given by (A4.7), which yields the solution given as the system equations (4.19) in the text.

$$\text{(A4.7a)} \quad [X_1(t) - X_1^*] = V_{11}e^{\Gamma_1 t}V_{11}^{-1}[X_1(0) - X_1^*]$$

$$\text{(A4.7b)} \quad [X_2(t) - X_2^*] = V_{21}e^{\Gamma_1 t}V_{11}^{-1}[X_1(0) - X_1^*]$$

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9 The general form of exponential matrix e^{Γ}, where Γ is an (n×n) matrix, is defined by

$$e^{\Gamma} \equiv \sum_{k=0}^{\infty} \left(\frac{\Gamma^k}{k!}\right).$$

However, if Γ is a diagonal matrix, then the exponential matrix is expressed as

$$e^{\Gamma} = \begin{bmatrix} e^{\gamma_1} & & & \\ & \cdot & & \\ & & e^{\gamma_i} & \\ & & & \cdot \\ & & & & e^{\gamma_n} \end{bmatrix}, \quad \text{if} \quad \Gamma = \begin{bmatrix} \gamma_1 & & & \\ & \cdot & & \\ & & \gamma_i & \\ & & & \cdot \\ & & & & \gamma_n \end{bmatrix}$$

CHAPTER 5

FISCAL POLICY, THE CURRENT ACCOUNT AND MACROECONOMIC ADJUSTMENT

5.1 Introduction

The current account and macroeconomic adjustment are the complex responses to not only the changes in external environments such as imported input price shock but also the changes in domestic economic policies. Fiscal policy in Korea, as already mentioned in chapter 3, played an important role in economic growth and in reducing the domestic investment-savings gap (i.e. the current account deficit). The theoretical effects of fiscal policy changes can readily be examined by extending the basic model set out in chapter 4.

Since we are interested in the effects of fiscal policy, the only extension required is to introduce the redistributive role of government. This involves the changes in the flow budget constraints of both the private and government sectors so that the model explicitly incorporates fiscal policy instruments. The basic framework other than the budget constraints remains unchanged, and the variables and notation are the same as those in chapter 4 unless otherwise defined.

We consider five fiscal policies : a proportional value-added tax (τ_1) levied on consumption C ; a proportional tax (τ_2) levied on capital income $Q_K K$; a proportional tax (τ_3) levied on labour income [1] $Q-\pi N-Q_K K$; a proportional subsidy or investment tax credit (τ_4) on gross investment I ; a proportional tariff (τ_5) on imported input N. These experiments of fiscal policy changes are the open-economy extension of Hall (1971), Abel and Blanchard (1983), and Judd (1985a) which examine the effects of similar fiscal

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[1] Since the gross output function Q and the real value-added output function $F(K,\bar{L};\pi) = Q(K,N,(K,\bar{L};\pi),\bar{L}) - \pi N(K,\bar{L};\pi)$ have been assumed to be linearly homogenous (see chapter 4), the Euler Theorem holds for both Q and F functions.

policy changes on consumption and/or investment in a closed economy with perfect foresight.

5.2 The Model and Dynamic Solution

Consider the case where there is no government bond financing. Then, the government spending is financed by the various current tax revenues and hence the government budget is always balanced.[2] The government collects taxes from value-added consumption, capital income, labour income, and imports of intermediate input to finance government consumption and the investment subsidy. Therefore, the issues relating to current tax financing versus future tax financing by issuing bonds (i.e. Ricardian Equivalence) are not dealt with in this chapter. All the government policies considered in this chapter are balanced budget policies.

Then the government budget constraint becomes :

$$(5.1)\quad \tau_1 C_t + \tau_2 Q_K(K_t,N_t,\bar{L})K_t + \tau_3[Q(K_t,N_t,\bar{L}) - \pi N_t - Q_K(K_t,N_t,\bar{L})K_t] - \tau_4 I_t + \tau_5 \pi N_t - G_t = 0$$

where G is the government consumption, and all the government policy variables (G and τ_i for i = 1, ...,5) are assumed to be preannounced. For simplicity, it is assumed that the government consumption does not enter the private sector's utility function.[3]

Since the government always keeps the budget balanced, the private budget constraint coincides with the current account equation of the economy as a whole. Taking into account the government's role of redistribution, the relevant budget constraint for the private sector becomes :

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[2] For the Korean case, the government budget deficit has been kept at fairly constant ratio to GDP since 1960. The ratio of budget deficit to GDP was 3% on average during 1960s and 1970s, and then fell to 1.3% on average during 1980s.

[3] For the case where the government'spending enters the private sector's utility function, see Aschauer and Greenwood (1985) and Djajic (1986, 1987).

$$(5.2)\quad \dot{B}_t = R(B_t) + Q(K_t,N_t,\bar{L}) - \pi N_t - C_t - I_t - h(\frac{\dot{K}_t}{K_t})\,K_t - G_t$$

$$= R(B_t) + (1-\tau_3)Q(K_t,N_t,\bar{L}) + (\tau_3-\tau_2)Q_K(K_t,N_t,\bar{L})K_t$$

$$- (1+\tau_1)C_t - (1-\tau_3+\tau_5)\pi N_t - (1-\tau_4)I_t - h(\frac{\dot{K}_t}{K_t})K_t$$

which is the current account equation, since G_t equals the net tax revenue $[\tau_1 C_t + \tau_2 Q_K K + \tau_3(Q-\pi N-Q_K K) - \tau_4 I + \tau_5 \pi N]$ by the government budget constraint (5.1). All notation and other constraints are the same as those in chapter 4 with the exception of tax parameters. Hence, the agent who is endowed with perfect foresight chooses $\{C_t, I_t, N_t\}$ to maximize the lifetime utility (4.1) subject to the constraints (4.3) and (5.2), given the known government policy and exogenous variables. We can rewrite the agent's optimization problem as follows :

$$(5.3)\quad \underset{\{C_t\, I_t\, N_t\}}{\text{maximize}}\quad \tilde{U} = \int_0^\infty U(C_t)e^{-\rho t}dt$$

$$\text{subject to}\quad \dot{K}_t = I_t - \delta K_t$$

$$\dot{B}_t = R(B_t) + (1-\tau_3)Q(K_t,N_t,\bar{L}) + (\tau_3-\tau_2)Q_K(K_t,N_t,\bar{L})K_t$$

$$- (1+\tau_1)C_t - (1-\tau_3+\tau_5)\pi N_t - (1-\tau_4)I_t - h(\frac{\dot{K}_t}{K_t})K_t$$

K_0 and B_0 are given.

Then the current-value Hamiltonian is given as (5.4) where λ_t and ψ_t are the respective shadow prices of capital and output :

$$(5.4)\quad H = U(C_t) + \lambda_t[I_t - \delta K_t]$$

$$+ \psi_t[R(B_t) + (1-\tau_3)Q(K_t,N_t,\bar{L}) + (\tau_3-\tau_2)Q_K(K_t,N_t,\bar{L})K_t$$

$$- (1+\tau_1)C_t - (1-\tau_3+\tau_5)\pi N_t - (1-\tau_4)I_t - h(\frac{\dot{K}_t}{K_t})K_t] .$$

The first order conditions can be obtained as equations (5.5) :

$$(5.5a)\quad \psi_t = \frac{1}{(1+\tau_1)} U'(C_t)$$

$$(5.5b)\quad \lambda_t = \psi_t [(1-\tau_4) + h'(\frac{\dot{K}_t}{K_t})]$$

$$(5.5c)\quad \pi = \frac{1}{(1-\tau_3+\tau_5)} [(1-\tau_3)Q_N(K_t,N_t,\bar{L}) + (\tau_3-\tau_2)Q_{KN}(K_t,N_t,\bar{L})K_t]$$

$$\text{or} \quad N_t = N(K_t,\bar{L};\ \pi,\tau_2,\tau_3,\tau_5)$$

$$(5.5d)\quad \dot{\lambda}_t = (\rho+\delta)\lambda_t - \psi_t [\ (1-\tau_2)Q_K\ (K_t,N_t,\bar{L}) + (\tau_3-\tau_2)Q_{KK}(K_t,N_t,\bar{L})K_t - h(\frac{\dot{K}_t}{K_t}) + (\frac{I_t}{K_t})\ h'(\frac{\dot{K}_t}{K_t})\ ]$$

$$(5.5e)\quad \dot{\psi}_t = \psi_t [\ \rho - R'(B_t)\ ]\ .$$

The above first order conditions are equivalent to the equations (4.9) except that equations (5.5) include the government's tax policy variables. The transversality conditions for the agent's optimization problem are the same as the conditions in (4.7). Since the concavity of the current-value Hamiltonian (5.4) in its control and state variables is easily verified, the solution which satisfies the first order conditions (5.5) and transversality conditions (4.7) is optimal. That is, the conditions (5.5) and (4.7) are sufficient for the maximum, given the concavity of the Hamiltonian.

By the same solution procedure of dynamic optimization described in chapter 4, we can obtain the following equations of motion of the system from the first order and transversality conditions :

$$(5.6a)\quad \dot{K}_t = I_t - \delta K_t = x(q_t-1+\tau_4)K_t$$

$$\text{where} \quad x(q_t-1+\tau_4) \gtreqless 0 \quad \text{as} \quad q_t-1+\tau_4 \gtreqless 0,$$

$$x'(q_t-1+\tau_4) > 0 \quad \text{for all} \quad q_t-1+\tau_4$$

$$(5.6b)\quad \dot{B}_t = R(B_t) + (1-\tau_3)Q(K_t,N(K_t,\bar{L};\ \pi,\tau_2,\tau_3,\tau_5),\bar{L})$$
$$+ (\tau_3-\tau_2)Q_K(K_t,N(K_t,\bar{L};\ \pi,\tau_2,\tau_3,\tau_5),\bar{L})K_t - (1+\tau_1)C_t$$
$$- (1-\tau_3+\tau_5)\pi N(K_t,\bar{L};\ \pi,\tau_2,\tau_3,\tau_5) - (1-\tau_4)\{x(q_t-1+\tau_4) + \delta\}K_t$$
$$- h(x(q_t-1+\tau_4))K_t$$

$$(5.6c)\quad \dot{C}_t = \frac{-C_t}{\theta(C_t)}[\rho - R'(B_t)]$$

$$\text{where } \theta(C_t) = \frac{-U''(C_t)C_t}{U'(C_t)}$$

$$(5.6d)\quad \dot{q}_t = [R'(B_t)+\delta]q_t - [(1-\tau_2)Q_K(K_t,N(K_t,\bar{L};\ \pi,\tau_2,\tau_3,\tau_5),\bar{L}) + (\tau_3-\tau_2)Q_{KK}K_t$$
$$- h(x(q_t-1+\tau_4)) + \{x(q_t-1+\tau_4) + \delta\}(q_t-1+\tau_4)]\ .$$

The system (5.6) needs little explanation, since the only change is the introduction of tax parameters. Thus, the steady-state defined by $\dot{K}_t = \dot{B}_t = \dot{C}_t = \dot{q}_t = 0$ and the optimal use of imported input, is characterized by the following equations which determine the unique values of q^*, B^*, K^*, C^*, N^* and w^* simultaneously.

$$(5.7a)\quad q^* = 1 - \tau_4$$

$$(5.7b)\quad R'(B^*) = \rho$$

$$(5.7c)\quad [R'(B^*) + \delta](1-\tau_4) = (1-\tau_2)Q_K(K^*,N^*,\bar{L}) + (\tau_3-\tau_2)Q^*_{KK}K^*$$

$$(5.7d)\quad (1+\tau_1)C^* = R(B^*) + (1-\tau_3)Q(K^*,N^*,\bar{L}) + (\tau_3-\tau_2)Q_K(K^*,N^*,\bar{L})K^*$$
$$- (1-\tau_3+\tau_5)\pi N^* - (1-\tau_4)\delta K^*$$

$$(5.7e)\quad \pi = \frac{1}{(1-\tau_3+\tau_5)}[(1-\tau_3)Q_N(K^*,N^*,\bar{L}) + (\tau_3-\tau_2)Q^*_{KN}K^*]$$

$$(5.7f)\quad w^*\bar{L} = Q(K^*,N^*,\bar{L}) - \pi N^* - Q_K(K^*,N^*,\bar{L})K^*\ .$$

Note that the tax-adjusted Tobin's q ($\tilde{q} = q+\tau_4$) is an increasing function of the investment tax credit (τ_4). Therefore, net investment is encouraged when $q + \tau_4 > 1$, and discouraged when $q + \tau_4 < 1$. The tax adjusted Tobin's q ($\tilde{q}$) is unity in the steady-state. The steady-state Tobin's q is $1 - \tau_4$, which implies the government can affect the Tobin's q, and hence the private investment by the changing its tax policy. All other steady-state relationships also contain the fiscal policy instruments. Again the steady-state value of net foreign assets is determined by the equation (5.7b). Equations (5.7c) and (5.7e) determine the steady-state values of capital stock and imported intermediate input. The steady-state consumption is also determined as the after-tax net national product [see equation (5.7d)]. The steady-state real wage (w^*) can be determined from the factor price frontier constructed by the equations (5.7c) and (5.7f) , given the relative price of the imported input (π) and tax policies.

Since we are interested in the path which converges to the long run steady-state, we can linearize the system of equations (5.6) around the steady-state values of K^*, B^*, C^*, and $q^* = 1 - \tau_4$, using the information in (5.7).[4] Thus, we obtain the linearized system (5.8) around the steady-state :

$$(5.8)\quad \begin{bmatrix} \dot{K}_t \\ \dot{B}_t \\ \dot{C}_t \\ \dot{q}_t \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & a_1K^* \\ \rho(1-\tau_4) & \rho & -(1+\tau_1) & -(1-\tau_4)a_1K^* \\ 0 & -a_2C^*/\theta^* & 0 & 0 \\ (1-\tau_2)a_3 & -(1-\tau_4)a_2 & 0 & \rho \end{bmatrix} \begin{bmatrix} K_t - K^* \\ B_t - B^* \\ C_t - C^* \\ q_t - q^* \end{bmatrix}$$

where $a_1 = x'(q^*-1+\tau_4) = x'(0) > 0$

$a_2 = - R''(B^*) > 0$

$a_3 = - F_{KK}(K^*,\bar{L};\pi) = - [Q_{KK} + Q_{KN}N_K] = - [Q_{KK}\, Q_{NN} - Q_{KN}^2] /Q_{NN} > 0$

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[4] We assume that the magnitude of the capital income tax rate is equal to that of the labor income tax rate ($\tau_2 = \tau_3$) for simplicity in the procedure of linearization. The qualitative results are not affected by these restrictions.

$$\rho = R'(B^*) > 0$$

$$\theta^* = -U''(C^*)C^*/U'(C^*) > 0 .$$

There exists a unique convergent path to the steady-state since there are two stable (negative) eigenvalues and two unstable (positive) eigenvalues of the transition matrix in (5.8). They are again obtained by solving the characteristic equation of the transition matrix in (5.8) as follows :

$$(5.9) \quad \gamma_1 = \frac{\rho - \sqrt{\rho^2 + 2(P - D)}}{2} < 0 \quad \gamma_2 = \frac{\rho - \sqrt{\rho^2 + 2(P + D)}}{2} < 0$$

$$\gamma_3 = \frac{\rho + \sqrt{\rho^2 + 2(P - D)}}{2} > 0 \quad \gamma_4 = \frac{\rho + \sqrt{\rho^2 + 2(P + D)}}{2} > 0$$

where

$$P = \frac{(1+\tau_1)a_2C^*}{\theta^*} + a_1K^*\{(1-\tau_4)^2a_2 + (1-\tau_2)a_3\} > 0$$

$$D = \sqrt{P^2 - \frac{4(1+\tau_1)(1-\tau_2)a_1a_2a_3C^*K^*}{\theta^*}}$$

$$= \sqrt{[\frac{(1+\tau_1)a_2C^*}{\theta^*} + a_1K^*\{(1-\tau_4)^2a_2-(1-\tau_2)a_3\}]^2+4(1-\tau_2)(1-\tau_4)^2a_1^2a_2a_3K^{*2}} > 0$$

$$P - D > 0, \ |\gamma_1| < |\gamma_2|, \ \gamma_3 < \gamma_4 .$$

Note that γ_i (i = 1,2,3,4), P, and D are not the same as those in chapter 4 because they incorporate the tax parameters. Since the number of negative and positive eigenvalues equals the number of predetermined and jump variables, respectively, we can solve the linearized system (5.8) for the saddle path to the long run steady-state using the method described in chapter 4. The saddle path is given as equations (5.10). The details of the solution are attached in the appendix to this chapter.

$$(5.10a)\quad K_t - K^* = \frac{1}{D}[(Z_1e^{\gamma_2 t} - Z_2e^{\gamma_1 t})(K_0 - K^*) + (1-\tau_4)a_1a_2K^*(e^{\gamma_1 t} - e^{\gamma_2 t})(B_0 - B^*)]$$

$$(5.10b)\quad B_t - B^* = \frac{1}{(1-\tau_4)a_1a_2K^*D}[Z_1Z_2(e^{\gamma_2 t} - e^{\gamma_1 t})(K_0 - K^*)$$

$$+ (1-\tau_4)a_1a_2K^*(Z_1e^{\gamma_1 t} - Z_2e^{\gamma_2 t})(B_0 - B^*)]$$

$$(5.10c)\quad C_t - C^* = \frac{1}{(1-\tau_4)\theta^*\gamma_1\gamma_2a_1K^*D}[C^*Z_1Z_2(\gamma_2e^{\gamma_1 t} - \gamma_1e^{\gamma_2 t})(K_0 - K^*)$$

$$+ (1-\tau_4)a_1a_2C^*K^*(Z_2\gamma_1e^{\gamma_2 t} - Z_1\gamma_2e^{\gamma_1 t})(B_0 - B^*)]$$

$$(5.10d)\quad q_t - q^* = \frac{1}{a_1K^*D}[(Z_1\gamma_2e^{\gamma_2 t} - Z_2\gamma_1e^{\gamma_1 t})(K_0 - K^*)$$

$$+ (1-\tau_4)a_1a_2K^*(\gamma_1e^{\gamma_1 t} - \gamma_2e^{\gamma_2 t})(B_0 - B^*)]$$

$$(5.10e)\quad \dot{B}_t = \frac{1}{(1-\tau_4)a_1a_2K^*D}[Z_1Z_2(\gamma_2e^{\gamma_2 t} - \gamma_1e^{\gamma_1 t})(K_0 - K^*)$$

$$+ (1-\tau_4)a_1a_2K^*(Z_1\gamma_1e^{\gamma_1 t} - Z_2\gamma_2e^{\gamma_2 t})(B_0 - B^*)]\ .$$

Note that $Z_1 = (1-\tau_2)a_1a_3K^* + \gamma_1\gamma_3 > 0$ and $Z_2 = (1-\tau_2)a_1a_3K^* + \gamma_2\gamma_4 < 0$ are different from those in chapter 4. K_0 and B_0 are the given initial capital stock and net foreign assets. Again the current account path (5.10e) is derived by differentiating the net foreign assets path (5.10b) with respect to time. The saddle path to the long run steady-state is determined by the constant parameters, the eigenvalues of the transition matrix, and expectations on the long run steady-state values of the predetermined variables. The speed of adjustment of the economy to the steady-state depends on the relative size of the stable (negative) eigenvalues, γ_1 and γ_2.

5.3 The Effects of Fiscal Policies

5.3.1 Long Run Effects

Suppose that the economy is in the steady-state initially, and denote the initial steady-state and the new steady-state with time subscript 0 and superscript *, respectively. As can be seen in the saddle path solution (5.10), the adjustment of the

economy is determined partly by the expectations of the long run steady-state values of the predetermined variables because of the perfect foresight assumption. Therefore, it is convenient to start with examining the equilibrium effects of fiscal policies in the long run. The long run responses of the endogenous variables of the system to the changes in fiscal policies can be obtained by differentiating the long run steady-state relationships (5.7), keeping all exogenous variables constant except the relevant fiscal policy instrument.

The long run equilibrium effects of balanced budget fiscal policies are summarized in Table 5.1. The formal derivation of the effects are provided in equations (A5.5) ~ (A5.9) in the appendix to this chapter. If there is any change in tax policy, the government spending is assumed to change accordingly to ensure budget balance. The long run effect of the balanced budget expansion in government spending financed by the consumption tax is a decrease in private consumption. The production sector of the economy is not affected by the change in the consumption tax. The effects of the capital income tax and labor income tax are similar. The capital stock, consumption and real wage decrease in the new steady-state. The use of the imported intermediate input decreases as a result of the increase in the capital income tax. When the labor income tax is increased, the use of the imported input does not change unless the magnitudes of the capital income tax rate and of the labor income tax rate are significantly different from each other initially.[5] However, the levels of Tobin's q and net foreign assets in the new steady-state are the same as those in the initial steady-state, although they might change during the transitional periods with the changes in consumption tax, capital income tax, and labor income tax. Another feature to note is that the redistributive effects of the tax on capital income is severely limited since the capital tax depresses real wage in the long run. This result is similar to those in the literature dealing with the optimal capital income tax such as Judd (1985b) and Chamley (1986).

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[5] If the magnitude of the initial labor income tax rate is much smaller than that of the initial capital income tax rate, the imported input use decreases with the increase of labor income tax (see the appendix to this chapter).

Table 5.1

Long Run Steady-State Effects of Different Fiscal Policies

	$d\tau_1>0$	$d\tau_2>0$	$d\tau_3>0$	$d\tau_4>0$	$d\tau_5>0$	$d\pi>0$
Tobin's q (q)	0	0	0	-	0	0
Tax-Adjusted Tobin's q ($q+\tau_4$)	0	0	0	0	0	0
Capital Stock (K)	0	-	-	+	-	-
Imported Intermediate Input (N)	0	-	0	+	-	-
Consumption (C)	-	-	-	+	-	-
Net Foreign Assets (B)	0	0	0	0	0	0
Real Wage (w)	0	-	-	+	0	-

Note : See appendix for formal derivations.

The qualitative effects of a balanced budget expansion of the investment tax credit (τ_4) are different from those of other fiscal policies. The Tobin's q in the new steady-state becomes smaller than that of initial steady-state, while the tax-adjusted Tobin's q ($q + \tau_4$) is unaffected in the long run. The long run capital stock, imported intermediate input use, and consumption increase. The real wage in the new steady-state also increases reflecting the long run response of capital stock along the factor price frontier.

Finally, a balanced budget expansion financed by an increase in the tariff results in the long run decreases in the capital stock, imported input use, and consumption. Unlike the increase in the price of the imported intermediate input, however, the increase in the tariff does not reduce the real wage.

5.3.2 Transitional Effects

As already mentioned, the main objective in this chapter is to examine the adjustment of the economy following the changes in fiscal policies. The transitional time path of the economy following a permanent increase in each tax can be obtained by plugging each set of equations (A5.5) ~ (A5.9) into the saddle path solution (5.10), respectively. Note again that the saddle path to a new steady-state is expressed only in terms of K, B, and the model's parameters including eigenvalues. Then, the transitional

dynamics result in the set of equations (5.11) ~ (5.13), where D, Z_1, a_1, a_2, a_3, θ^*, C^*, $K^* > 0$, Z_2, γ_1, γ_2, < 0, and $|\gamma_1| < |\gamma_2|$.

Value-Added Consumption Tax ($d\tau_1 > 0$)

The long run equilibrium effects of fiscal expansion financed by a permanent increase in consumption tax (τ_1) have been discussed in the previous section (also see the equations (A5.5) in the appendix to this chapter). The only long run effect is the decrease in the consumption level, and moreover the adjustment to a new steady-state with a lower consumption is immediate. The production side of the economy is not affected by the increase in consumption tax. The net effect is, therefore, that the private consumption is completely crowded out by the fiscal expansion. Since there is no change in the long run productive capacity, the economy moves quickly to a new equilibrium with a lower private consumption level than before.

This result of the increase in consumption tax in an infinite horizon perfect foresight model supports the assertion that the value-added tax levied on consumption is more conducive to economic growth and balance-of-payments stability than the capital income tax.

Capital Income Tax ($d\tau_2 > 0$)

The long run equilibrium effects of a balanced budget increase in the tax on capital income (τ_2) are given by equations (A5.6) in the appendix to this chapter. The transitional time path of the system after a permanent increase in τ_2 can be obtained by substituting (A5.6a) and (A5.6e) in the appendix into the saddle path solution (5.10), since the saddle path is characterized by the (perfect foresight) expectations on the state variables, K and B. Therefore, the resulting solution for the transitional dynamics to a new steady-state can be expressed as follows :

$$\text{(5.11a)} \quad K_t - K^* = \left[\frac{F_K^* + F_{KK}^* K^*}{a_3 D(1-\tau_2)}\right](Z_1 e^{\gamma_2 t} - Z_2 e^{\gamma_1 t})d\tau_2$$

$$\text{(5.11b)} \quad B_t - B^* = \left[\frac{Z_1 Z_2 (F_K^* + F_{KK}^* K^*)}{a_1 a_2 a_3 K^* D(1-\tau_2)(1-\tau_4)}\right](e^{\gamma_2 t} - e^{\gamma_1 t})d\tau_2$$

$$(5.11c)\quad C_t - C^* = [\frac{C^*Z_1Z_2(F_K^* + F_{KK}^*K^*)}{\theta^*\gamma_1\gamma_2a_1a_3K^*D(1-\tau_2)(1-\tau_4)}](\gamma_2e^{\gamma_1t} - \gamma_1e^{\gamma_2t})d\tau_2$$

$$(5.11d)\quad q_t - q^* = [\frac{F_K^* + F_{KK}^*K^*}{a_1a_3K^*D(1-\tau_2)}](Z_1\gamma_2e^{\gamma_2t} - Z_2\gamma_1e^{\gamma_1t})d\tau_2$$

$$(5.11e)\quad \dot{B}_t = [\frac{Z_1Z_2(F_K^* + F_{KK}^*K^*)}{a_1a_2a_3K^*D(1-\tau_2)(1-\tau_4)}](\gamma_2e^{\gamma_2t} - \gamma_1e^{\gamma_1t})d\tau_2 .$$

The motion of the transitional dynamics (5.11) can also be traced in Figure 5.1, if the appropriate numbers are assigned to the eigenvalues and parameters which satisfy the conditions for the sign and relative size. At time zero when the permanent increase in the balanced budget tax on capital income occurs, the Tobin's q drops by the amount $-[\frac{F_K^* + F_{KK}^*K^*}{a_1a_3K^*D(1-\tau_2)}](Z_1\gamma_2 - Z_2\gamma_1)d\tau_2 > 0$ giving the signal to reduce investment. As time evolves, the Tobin's q starts to increase until it reaches the original steady-state value, $1-\tau_4$. The capital stock decreases continuously from K_0 to K^*, until the economy arrives at the point where $q = 1-\tau_4$, since the Tobin's q is less than $1-\tau_4$ during the transitional period. Note that there is no jump in the motion of K which is also evident from (5.11a).

At time zero when the capital income tax is increased, consumption also drops by the amount $\frac{1}{1+\tau_1}[Q_K^*K^* + \frac{(1-\tau_4)(F_K^*+F_{KK}^*K^*)}{a_3D(1-\tau_2)}\{\rho D - (\gamma_1-\gamma_2)\gamma_3\gamma_4\}]d\tau_2 > 0$ which is smaller than the long run drop in consumption, and continued to decline until it reaches a new steady-state level C^*.[6]

The current account shows a surplus immediately after the permanent increase in τ_2, and then turns into a deficit until the economy reaches a new steady-state. These results are similar to the responses of consumption and investment to the permanent increase in the imported input price (π). The quick drop in consumption relative to investment results in a surplus immediately after the shock with a reversal of the trend

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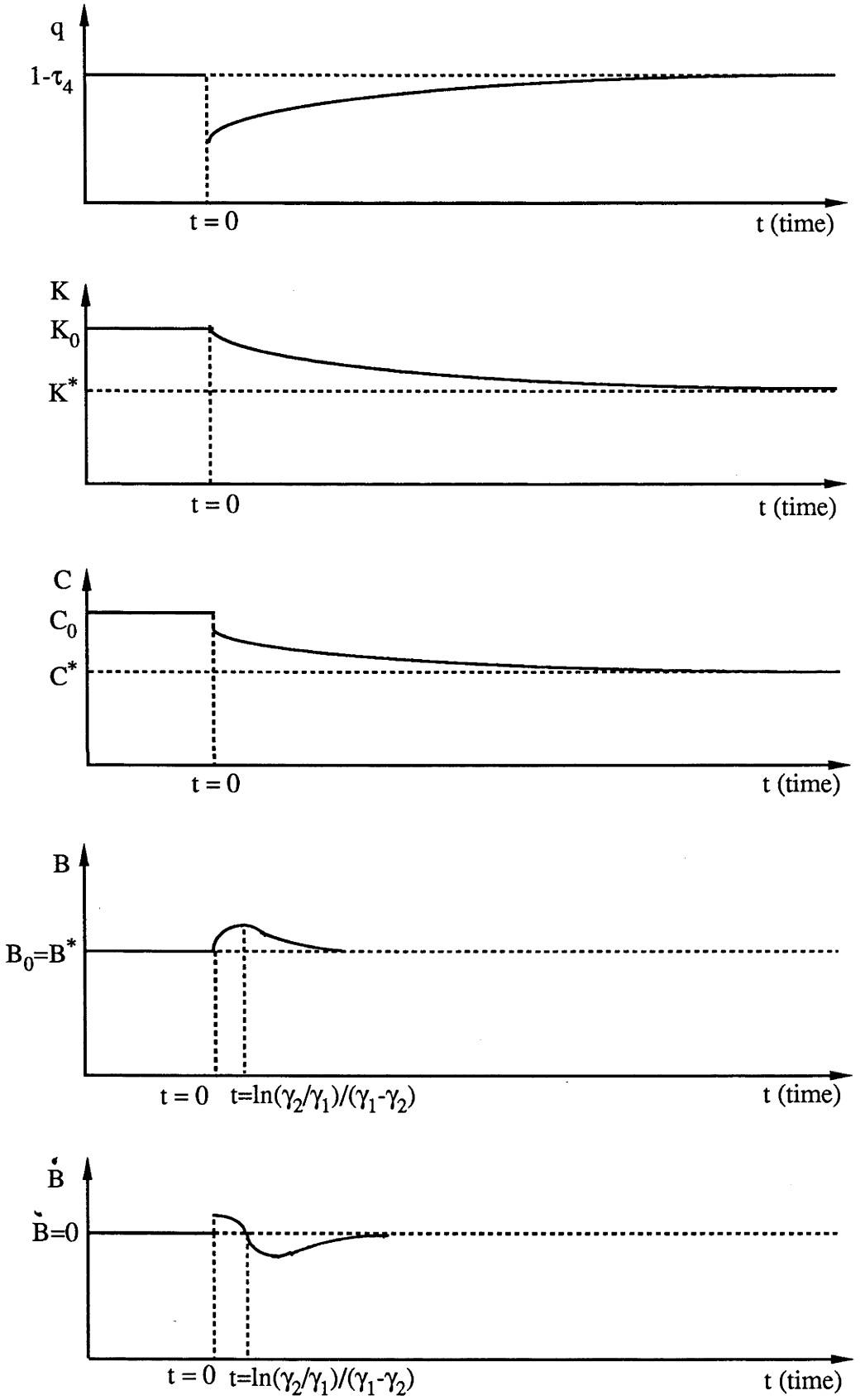
6 The initial drop in consumption can be obtained by subtracting $C_0 - C^*$ in (5.11c) from the long run drop in consumption $-dC = \frac{1}{1+\tau_1}[Q_K^*K^* + \frac{\rho(1-\tau_4)(F_K^* + F_{KK}^*K^*)}{a_3(1-\tau_2)}]d\tau_2 > 0$ in (A5.6c). Note that $C_t - C^*$ is positive for all t in (5.11c).

Figure 5.1

The Effects of an Unanticipated, Permanent Increase in τ_2



resulting in a deficit in the current account later. The time at which the current account turns into a deficit depends on the relative size of the stable eigenvalues, γ_1 and γ_2 [$t = \frac{1}{\gamma_1 - \gamma_2} ln\,(\frac{\gamma_2}{\gamma_1})$]. Of course, the stable eigenvalues in this chapter are different from those of chapter 4 in the sense that they incorporate the government policies. Finally, as mentioned in the previous section the capital income tax is shifted to labor and real wages decline in the long run.

Labour Income Tax ($d\tau_3 > 0$)

The transitional time path of the system after a permanent increase in the labor income tax (τ_3) is obtained by substituting (A5.7a) and (A5.7e) into the saddle path solution (5.10). Since the qualitative effects are similar to those of the increase in τ_2, they can be illustrated with Figure 5.1. The solution for the transitional dynamics is given by (5.12) :

$$\text{(5.12a)} \quad K_t - K^* = [\frac{K^*}{D(1-\tau_2)}](Z_1 e^{\gamma_2 t} - Z_2 e^{\gamma_1 t})d\tau_3$$

$$\text{(5.12b)} \quad B_t - B^* = [\frac{Z_1 Z_2 K^*}{a_1 a_2 K^* D(1-\tau_2)(1-\tau_4)}](e^{\gamma_2 t} - e^{\gamma_1 t})d\tau_3$$

$$\text{(5.12c)} \quad C_t - C^* = [\frac{Z_1 Z_2 C^* K^*}{\theta^* \gamma_1 \gamma_2 a_1 K^* D(1-\tau_2)(1-\tau_4)}](\gamma_2 e^{\gamma_1 t} - \gamma_1 e^{\gamma_2 t})d\tau_3$$

$$\text{(5.12d)} \quad q_t - q^* = [\frac{K^*}{a_1 K^* D(1-\tau_2)}](Z_1 \gamma_2 e^{\gamma_2 t} - Z_2 \gamma_1 e^{\gamma_1 t})d\tau_3$$

$$\text{(5.12e)} \quad \dot{B}_t = [\frac{Z_1 Z_2 K^*}{a_1 a_2 K^* D(1-\tau_2)(1-\tau_4)}](\gamma_2 e^{\gamma_2 t} - \gamma_1 e^{\gamma_1 t})d\tau_3$$

Again the capital stock starts to decrease continuously in response to the signal of Tobin's q falling below its steady-state value. The long run effect on the capital stock of the labor income tax is a decumulation of capital. Consumption also drops initially and decreases further until it reaches a lower new steady-state level. Reflecting the

consumption and investment behavior the current account shows a surplus immediately after the policy shock and then turns into a deficit from time $t = \frac{1}{\gamma_1 - \gamma_2} ln\,(\frac{\gamma_2}{\gamma_1})$.

Investment Tax Credit ($d\tau_4 > 0$)

The transitional dynamics after a permanent increase in the investment subsidy (τ_4) can be obtained by substituting (A5.8a) and (A5.8e) into the saddle path solution (5.10), which yields the following system :

$$\text{(5.13a)} \quad K_t - K^* = -\left[\frac{(\rho+\delta)}{a_3 D(1-\tau_2)}\right](Z_1 e^{\gamma_2 t} - Z_2 e^{\gamma_1 t})d\tau_4$$

$$\text{(5.13b)} \quad B_t - B^* = -\left[\frac{Z_1 Z_2(\rho+\delta)}{a_1 a_2 a_3 K^* D(1-\tau_2)(1-\tau_4)}\right](e^{\gamma_2 t} - e^{\gamma_1 t})d\tau_4$$

$$\text{(5.13c)} \quad C_t - C^* = -\left[\frac{C^* Z_1 Z_2(\rho+\delta)}{\theta^* \gamma_1 \gamma_2 a_1 a_3 K^* D(1-\tau_2)(1-\tau_4)}\right](\gamma_2 e^{\gamma_1 t} - \gamma_1 e^{\gamma_2 t})d\tau_4$$

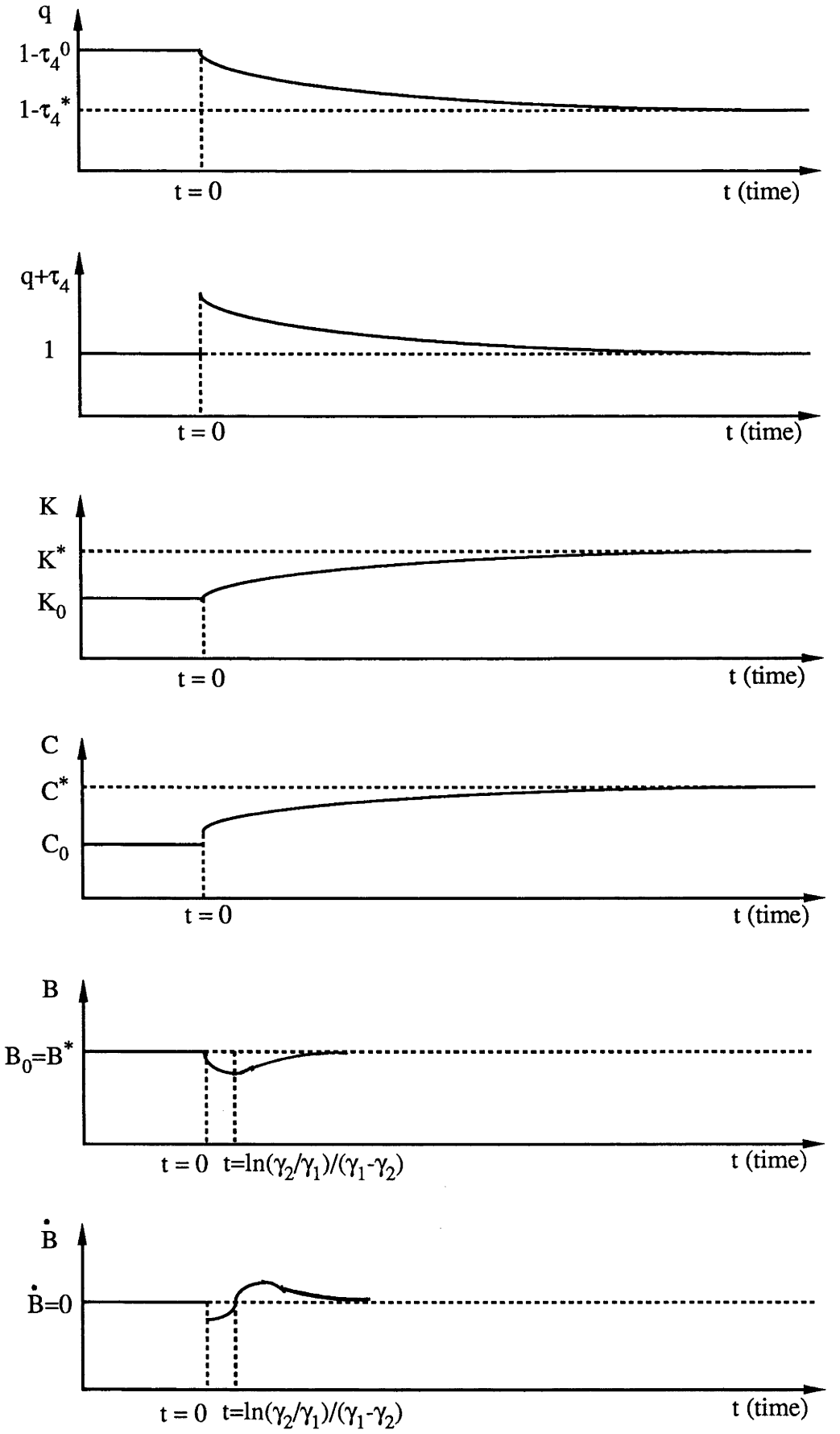
$$\text{(5.13d)} \quad q_t - q^* = -\left[\frac{(\rho+\delta)}{a_1 a_3 K^* D(1-\tau_2)}\right](Z_1 \gamma_2 e^{\gamma_2 t} - Z_2 \gamma_1 e^{\gamma_1 t})d\tau_4$$

$$\text{(5.13e)} \quad \dot{B}_t = -\left[\frac{Z_1 Z_2(\rho+\delta)}{a_1 a_2 a_3 K^* D(1-\tau_2)(1-\tau_4)}\right](\gamma_2 e^{\gamma_2 t} - \gamma_1 e^{\gamma_1 t})d\tau_4 .$$

The transitional dynamics (5.13) can also be visualized as Figure 5.2. At time zero when a permanent increase in τ_4 occurs, the Tobin's q exceeds the new steady-state level by the amount $-\left[\frac{(\rho+\delta)(Z_1\gamma_2 - Z_2\gamma_1)}{a_1 a_3 K^* D(1-\tau_2)}\right]d\tau_4 > 0$ because of the increase in τ_4. The tax-adjusted Tobin's q ($\tilde{q} = q_0 + \tau_4$), therefore, exceeds unity. As time evolves, the Tobin's q starts to decline and the tax-adjusted Tobin's q returns to its initial level, unity. For the whole adjustment period, the capital stock increases continuously until the tax-adjusted Tobin's q reaches unity.

Figure 5.2

The Effects of an Unanticipated, Permanent Increase in τ_4



Reflecting the rise in wealth, consumption jumps upward at time zero by the amount $\frac{1}{(1+\tau_1)}[\delta K^* + \frac{(1-\tau_4)(\rho+\delta)}{a_3(1-\tau_2)D}\{\rho D - (\gamma_1 - \gamma_2)\gamma_3\gamma_4\}]d\tau_4 > 0$ and then increases further until it reaches the new higher steady-state level.

The current account shows a deficit immediately after the permanent increase in τ_4, and then turns into a surplus until it reaches a balance eventually. The initial deficit is the outcome of the bigger increase in consumption relative to the increase in investment.

Import Tariff ($d\tau_5 > 0$)

The transitional dynamics of the system after a permanent increase in the import tariff (τ_5) can be obtained by substituting (A5.9a) and (A5.9e) into the saddle path solution (5.10). The resulting system is given as (5.14) :

$$\text{(5.14a)} \quad K_t - K^* = -[\frac{\pi Q^*_{KN}}{a_3 D Q^*_{NN}(1-\tau_2)}](Z_1 e^{\gamma_2 t} - Z_2 e^{\gamma_1 t})d\tau_5$$

$$\text{(5.14b)} \quad B_t - B^* = -[\frac{\pi Q^*_{KN} Z_1 Z_2}{a_1 a_2 a_3 K^* D Q^*_{NN}(1-\tau_2)(1-\tau_4)}](e^{\gamma_2 t} - e^{\gamma_1 t})d\tau_5$$

$$\text{(5.14c)} \quad C_t - C^* = -[\frac{\pi Q^*_{KN} C^* Z_1 Z_2}{\theta^* \gamma_1 \gamma_2 a_1 a_3 K^* D Q^*_{NN}(1-\tau_2)(1-\tau_4)}](\gamma_2 e^{\gamma_1 t} - \gamma_1 e^{\gamma_2 t})d\tau_5$$

$$\text{(5.14d)} \quad q_t - q^* = -[\frac{\pi Q^*_{KN}}{a_1 a_3 K^* D Q^*_{NN}(1-\tau_2)}](Z_1 \gamma_2 e^{\gamma_2 t} - Z_2 \gamma_1 e^{\gamma_1 t})d\tau_5$$

$$\text{(5.14e)} \quad \dot{B}_t = -[\frac{\pi Q^*_{KN} Z_1 Z_2}{a_1 a_2 a_3 K^* D Q^*_{NN}(1-\tau_2)(1-\tau_4)}](\gamma_2 e^{\gamma_2 t} - \gamma_1 e^{\gamma_1 t})d\tau_5$$

The transitional pattern of adjustments in investment, consumption and the current account after an increase in τ_5 is similar to that of the increase in the capital income tax or imported input price. Therefore, it can be explained with the help of Figure 5.1. The only difference is that the real wage is not depressed in the long run in the case of the increase in tariff. The import tariff is not shifted to labor income.

5.3.3 Changes among Taxes

It has been shown that the qualitative effects of a fiscal expansion financed by the increase in capital income tax are similar to those of an imported input price shock. The effects of an increase in the investment tax credit are symmetrical to those of capital income tax. The consumption tax falls entirely on consumption and has no long run effect on the production side of the economy and real wage. The import tariff has similar qualitative effects to the capital income tax, but the real wage is not depressed by an increase in the import tariff. The labor income tax also has similar qualitative effects to the capital income tax except that the imported input use is not much affected by the labor income tax.

The government may change its tax policies depending on its objective. When there is an imported input price hike, the government may respond to the shock with expansionary fiscal policy to counteract the contractionary effect of the shock and/or to make the private sector continue the precommitted investment plans. The possible combination of tax policies is the increase in consumption tax and investment tax credit (or the cut in capital income tax). One of the possible combination of the outcomes in this case is a fall in consumption and a rise in investment. This could be the case in Korea after the first oil shock. Another feature to note is that the increase in the capital income tax aiming at income redistribution in favor of labor will have limited effects, since the capital income tax ultimately depresses the real wage. The results in the previous section also suggest that the value-added tax levied on consumption is more conducive to economic growth and balance-of-payments stability than any other tax, but at the expense of the privates's welfare.

5.4 Conclusions

This chapter has analyzed the effects of a permanent increase in the value-added consumption tax, the capital income tax, the labour income tax, the investment subsidy and the import tariff, respectively.

The qualitative effects of the changes in the capital income tax, and the labour income tax are similar. When a permanent increase in one of these taxes occurs, the capital stock and consumption decrease and the current account shows an initial surplus followed by a deficit. The impact effect on the current account is a surplus, which is the outcome of the quick drop in consumption relative to investment. For the remaining period of adjustment, however, the current account shows a deficit. A permanent increase in the investment subsidy operates in the other direction. The capital stock and consumption increase, and the current account shows an initial deficit followed by a surplus. Unlike the capital income or labor income taxes, the consumption tax and import tariff do not affect the long run real wage. A balanced budget tax increase in the consumption tax completely crowds the private consumption out. The import tariff operates qualitatively in the same way as a capital income tax on the capital stock, the imported input use and consumption.

Facing an external shock such as a sudden increase in the price of an imported intermediate input, the economy can, in fact, respond in very complicated ways. The government which may have a different objective function from those of the private sector, can respond with a variety of policy combinations, and affect the economy's equilibrium in various ways. Although the government's objective is not explicitly introduced, this chapter has shown the possibility that the pattern of macroeconomic adjustment after external economic shocks could be affected and complicated by the government policies. This can provide one explanation for the empirical observation that the patterns of macroeconomic adjustment after the two oil-shocks differed from country to country.

Appendix to chapter 5

Solution for the Unique Saddle Path

Since the solution procedure for the unique saddle path to the long run steady-state is the same as described in the appendix to chapter 4, only the essential elements required for the solution are described in this appendix. The solution for the saddle path is again given by (A5.1) :

(A5.1a) $[X_1(t) - X_1^*] = V_{11}e^{\Gamma_1 t} V_{11}^{-1}[X_1(0) - X_1^*]$

(A5.1b) $[X_2(t) - X_2^*] = V_{21}e^{\Gamma_1 t} V_{11}^{-1}[X_1(0) - X_1^*]$

where $X_1 = [K\ B]'$ is the vector of predetermined variables, $X_2 = [C\ q]'$ is the vector of non-predetermined variables, Γ is the diagonal matrix with the negative and positive eigenvalues of the coefficient matrix in (5.8), and V is a conformable matrix with the associated eigenvectors of the coefficient matrix as columns, respectively.

The eigenvalues of the coefficient matrix (A) can be obtained by solving the characteristic equation of the matrix A, $A(\gamma) = |A - \gamma I| = \gamma^2(\gamma-\rho)^2 - [\frac{(1+\tau_1)a_2C^*}{\theta^*} + a_1K^*\{(1-\tau_4)^2a_2 + (1-\tau_2)a_3\}]\gamma(\gamma-\rho) + \frac{(1+\tau_1)(1-\tau_2)a_1a_2a_3C^*K^*}{\theta^*} = 0$. There are two negative eigenvalues (γ_1,γ_2) and two positive eigenvalues (γ_3,γ_4) as given in (5.9) in the text. Hence, the matrix Γ is expressed as (A5.2), where γ_i (i = 1,2,3,4), P, and D are not the same as those in chapter 4 because they incorporate tax parameters.

$$\text{(A5.2)}\quad \Gamma = \begin{bmatrix} \frac{\rho-\sqrt{\rho^2+2(P-D)}}{2} & 0 & 0 & 0 \\ 0 & \frac{\rho-\sqrt{\rho^2+2(P+D)}}{2} & 0 & 0 \\ 0 & 0 & \frac{\rho+\sqrt{\rho^2+2(P-D)}}{2} & 0 \\ 0 & 0 & 0 & \frac{\rho+\sqrt{\rho^2+2(P+D)}}{2} \end{bmatrix}$$

where

$$P = \frac{(1+\tau_1)a_2C^*}{\theta^*} + a_1K^*\{(1-\tau_4)^2a_2 + (1-\tau_2)a_3\} > 0$$

$$D = \sqrt{P^2 - \frac{4(1+\tau_1)(1-\tau_2)a_1a_2a_3C^*K^*}{\theta^*}}$$

$$= \sqrt{[\frac{(1+\tau_1)a_2C^*}{\theta^*} + a_1K^*\{(1-\tau_4)^2a_2-(1-\tau_2)a_3\}]^2 + 4(1-\tau_2)(1-\tau_4)^2a_1^2a_2a_3K^{*2}} > 0$$

$$P - D > 0, \ |\gamma_1| < |\gamma_2|, \ \gamma_3 < \gamma_4$$

The column eigenvectors V_i (i = 1,2,3,4) associated with the eigenvalues γ_i (i = 1,2,3,4) of the coefficient matrix (A) can be obtained by solving the matrix equation $[A - \gamma_i I]V_i = 0$ for V_i (i = 1,2,3,4) with the condition of normalization. The resulting matrix $V = [V_1\ V_2\ V_3\ V_4]$ is expressed as follows.

$$\text{(A5.3)} \quad V = \begin{bmatrix} V_{11} & V_{12} \\ V_{21} & V_{22} \end{bmatrix}$$

$$= \begin{bmatrix} \frac{-(1-\tau_4)\theta^*a_1a_2K^*\gamma_1}{\sqrt{A_1}} & \frac{-(1-\tau_4)\theta^*a_1a_2K^*\gamma_2}{\sqrt{A_2}} & \frac{(1-\tau_4)\theta^*a_1a_2K^*\gamma_3}{\sqrt{A_3}} & \frac{(1-\tau_4)\theta^*a_1a_2K^*\gamma_4}{\sqrt{A_4}} \\ \frac{-\theta^*Z_1\gamma_1}{\sqrt{A_1}} & \frac{-\theta^*Z_2\gamma_2}{\sqrt{A_2}} & \frac{\theta^*Z_1\gamma_3}{\sqrt{A_3}} & \frac{\theta^*Z_2\gamma_4}{\sqrt{A_4}} \\ \frac{a_2C^*Z_1}{\sqrt{A_1}} & \frac{a_2C^*Z_2}{\sqrt{A_2}} & \frac{-a_2C^*Z_1}{\sqrt{A_3}} & \frac{-a_2C^*Z_2}{\sqrt{A_4}} \\ \frac{-(1-\tau_4)\theta^*a_2\gamma_1^2}{\sqrt{A_1}} & \frac{-(1-\tau_4)\theta^*a_2\gamma_2^2}{\sqrt{A_2}} & \frac{(1-\tau_4)\theta^*a_2\gamma_3^2}{\sqrt{A_3}} & \frac{(1-\tau_4)\theta^*a_2\gamma_4^2}{\sqrt{A_4}} \end{bmatrix}$$

where $A_1 = Z_1^2(\theta^{*2}\gamma_1^2 + a_2^2C^{*2}) + \gamma_1^2(1-\tau_4)^2\theta^{*2}a_2^2(\gamma_1^2 + a_1^2K^{*2}) > 0$

$$A_2 = Z_2^2(\theta^{*2}\gamma_2^2 + a_2^2C^{*2}) + \gamma_2^2(1-\tau_4)^2\theta^{*2}a_2^2(\gamma_2^2 + a_1^2K^{*2}) > 0$$

$$A_3 = Z_1^2(\theta^{*2}\gamma_3^2 + a_2^2C^{*2}) + \gamma_3^2(1-\tau_4)^2\theta^{*2}a_2^2(\gamma_3^2 + a_1^2K^{*2}) > 0$$

$$A_4 = Z_2^2(\theta^{*2}\gamma_4^2 + a_2^2C^{*2}) + \gamma_4^2(1-\tau_4)^2\theta^{*2}a_2^2(\gamma_4^2 + a_1^2K^{*2}) > 0$$

$$Z_1 = (1-\tau_2)a_1a_3K^* + \gamma_1\gamma_3$$

$$= \frac{-[(1+\tau_1)a_2C^*/\theta^* + a_1K^*\{(1-\tau_4)^2a_2 - (1-\tau_2)a_3\}] + D}{2} > 0$$

$$Z_2 = (1-\tau_2)a_1a_3K^* + \gamma_2\gamma_4$$

$$= \frac{-[(1+\tau_1)a_2C^*/\theta^* + a_1K^*\{(1-\tau_4)^2a_2 - (1-\tau_2)a_3\}] - D}{2} < 0$$

The exponential matrix $e^{\Gamma_1 t}$ is defined as (A5.4), where Γ_1 is a diagonal matrix with negative (stable) eigenvalues.

$$\text{(A5.4)} \quad e^{\Gamma_1 t} = \begin{bmatrix} e^{\gamma_1 t} & 0 \\ 0 & e^{\gamma_2 t} \end{bmatrix}$$

Therefore, the solution for the unique saddle path to the long run steady-state is obtained by the formulae (A5.1) using the information in (A5.2) ~ (A5.4). The result is given by (5.10) in the text.

Long Run Equilibrium Effects of Fiscal Policy

The qualitative long run effects of various fiscal policy changes reported in Table 5.1 are obtained by differentiating the long run steady-state relationships (5.6) with respect to the relevant fiscal policy instruments. The assumption that the magnitude of capital income tax rate is equal to that of the labor income tax initially is maintained.

Value-Added Consumption Tax ($d\tau_1 > 0$)

(A5.5a) $dK = 0$

(A5.5b) $dN = 0$

(A5.5c) $dC = \frac{-C^*}{(1+\tau_1)}d\tau_1 < 0$

(A5.5d) $dw = 0$

(A5.5e) $dq = dB = 0$

Capital Income Tax ($d\tau_2 > 0$)

(A5.6a) $dK = -\left[\frac{F_K^* + F_{KK}^* K^*}{a_3(1-\tau_2)}\right] d\tau_2 < 0$

(A5.6b) $dN = \frac{Q_K^* Q_{KN}^*}{a_3(1-\tau_2)Q_{NN}^*} d\tau_2 < 0$

(A5.6c) $dC = \frac{-1}{(1+\tau_1)}\left[Q_K^* K^* + \frac{\rho(1-\tau_4)(F_K^* + F_{KK}^* K^*)}{a_3(1-\tau_2)}\right] d\tau_2 < 0$

(A5.6d) $dw = -\left[\frac{K^*(Q_K^* + Q_{KK}^* K^*)}{\bar{L}(1-\tau_2)}\right] d\tau_2 < 0$

(A5.6e) $dq = dB = 0$

Labor Income Tax ($d\tau_3 > 0$)

(A5.7a) $dK = -\left[\frac{K^*}{(1-\tau_2)}\right] d\tau_3 < 0$

(A5.7b) $dN = 0$ [7]

(A5.7c) $dC = -\frac{1}{(1+\tau_1)}\left[w^*\bar{L} + \frac{\rho K^*(1-\tau_4)}{(1-\tau_2)}\right] d\tau_3 < 0$

(A5.7d) $dw = \left[\frac{Q_{KK}^* K^{*2}}{\bar{L}(1-\tau_2)}\right] d\tau_3 < 0$

(A5.7e) $dq = dB = 0$

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[7] This result is due to the assumption of $\tau_2 = \tau_3$ initially. However, the magnitude of the initial labor income tax rate is smaller than that of the capital income tax rate ($\tau_3 < \tau_2$), the imported input use decreases. Before imposing the assumption ($\tau_2 = \tau_3$), the change in the imported input use is expressed as $dN = \frac{-Q_{KN}K^*}{(1-\tau_3)Q_{NN}}\left[1-\left\{\frac{(1-\tau_2)(1-\tau_3)Q_{KK}Q_{NN}-(1-\tau_2)^2 Q_{KN}^2}{(1-2\tau_2+\tau_3)(1-\tau_3)-Q_{KK}Q_{NN}(1-\tau_2)^2 Q_{KN}^2}\right\}\right] d\tau_3 \gtreqless 0$ as $\tau_3 \gtreqless \tau_2$.

Investment Tax Credit ($d\tau_4 > 0$)

(A5.8a) $dK = [\frac{(\rho+\delta)}{a_3(1-\tau_2)}]\, d\tau_4 > 0$

(A5.8b) $dN = -\frac{(\rho+\delta)Q^*_{KN}}{a_3(1-\tau_3)Q^*_{NN}}\, d\tau_4 > 0$

(A5.8c) $dC = \frac{1}{(1+\tau_1)}[\delta K^* + \frac{\rho(\rho+\delta)(1-\tau_4)}{a_3(1-\tau_2)}]\, d\tau_4 > 0$

(A5.8d) $dw = [\frac{(\rho+\delta)K^*}{\bar{L}(1-\tau_2)}]\, d\tau_4 > 0$

(A5.8e) $dq = -\, d\tau_4 < 0, \quad dB = 0$

Import Tariff ($d\tau_5 > 0$)

(A5.9a) $dK = \frac{\pi Q^*_{KN}}{a_3(1-\tau_2)Q^*_{NN}}\, d\tau_5 < 0$

(A5.9b) $dN = -\frac{\pi Q^*_{KK}}{a_3(1-\tau_3)Q^*_{NN}}\, d\tau_5 < 0$

(A5.9c) $dC = \frac{1}{(1+\tau_1)}[\frac{\rho\pi(1-\tau_4)Q^*_{KN}}{a_3(1-\tau_2)Q^*_{NN}} - \pi N^*]d\tau_5 < 0$

(A5.9d) $dw = 0$

(A5.9e) $dq = dB = 0$

CHAPTER 6

STRATEGIC INTERACTION BETWEEN THE GOVERNMENT AND PRIVATE SECTORS : Econometric Estimation of the Korean Economy

6.1 Introduction

In the previous chapters, we have analyzed some theoretical effects of exogenous economic shocks (e.g. imported input price shock in chapter 4, fiscal policy shock in chapter 5) in highly aggregated frameworks. It was assumed that the economy was composed of identical representative agents and the government was regarded as one. The only role of the government considered so far was a redistributional one by distortionary taxation.

Although the theoretical analyses in the previous chapters can provide some useful insights, they are not sufficient for successful empirical application. To apply the theoretical framework to real data, we should be clearer about the role of government, the information structure, and also the specific features of the economy in which we are interested.

Firstly, the role of the government is considered in more detail. It is quite obvious that in most developing countries, including Korea, the government played a considerable role in economic planning and in the implementation of the plan. Therefore, the government may have had its own objective (or social welfare function) and used specific policy instruments to achieve its objective. Then the equilibrium of the economy is determined by the interaction between government and private sector optimal decisions.

The interactions between decentralized agents have usually been analyzed using dynamic game theory. For example, Pindyck (1977) derives optimal stabilization policy rules under the assumption that monetary and fiscal policy are implemented by separate authorities facing conflicting objectives. Oudiz and Sachs (1985) and McKibbin and

Sachs (1987) apply dynamic game theory to investigate the gains from international policy coordination. Conway (1987) is another example of the application of dynamic game theory to the interaction between government and private sectors which is the main theme of this chapter.

Strategic behavior in the literature is usually divided into four types : Nash vs. Stackelberg behavior, and open-loop vs. closed-loop strategies. With Nash behavior, both actors make their decisions simultaneously taking the other's decision as fixed. In the Stackelberg behavior, however, one of the agents plays the role of a leader and the other a follower. The leader announces his decision and the follower makes his decision given the leader's decision. Within a dynamic context, if each agent makes his optimal *decision (or policy action)* at the beginning of the game and then does not change that *decision* throughout the period, the strategy is called an open-loop strategy. On the other hand, if each agent makes a *control rule* at the beginning of the game and uses the rule to revise his decision according to the state of the economy, the strategy is called a closed-loop strategy. In the deterministic case with perfect foresight, the explicit solutions for each case can be obtained by assuming explicit quadratic objective functions for the players.[1] In this chapter, we assume an open-loop Stackelberg game between the government and the private sector, because of its simplicity relative to a closed-loop game.

Secondly, some of the restrictive assumptions adopted for convenience in the theoretical analysis will be relaxed in the empirical analysis. The assumption of perfect foresight is replaced (from section 6.3 onwards) by the assumption that the economic agent has rational expectations about the uncertain future variables. The risk free real interest rate is assumed to be exogenously given by the world real interest rate. The economy is assumed to be a surplus-labor economy and the real wage is exogenously determined by government. Then, the labor employed is determined endogenously by the profit maximizing firm, although this is a testable assumption. In addition, for the

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[1] See Miller and Salmon (1985) and Oudiz and Sachs (1985) for the detailed derivation of the solutions of four types of dynamic game. These are examples of dynamic games between two actors. Wishart and Olsder (1979), and Jibbe et al. (1984) show the procedure of the Stackelberg solution under a dynamic game between a single leader and multiple n-followers.

purpose of econometric estimation, explicit functional forms are given for the utility and gross output functions. Finally, all the variables except price variables are expressed in *per capita terms*.

6.2 Structure of the Economy : One Leader and Two Followers

Since the main purpose of this chapter is to estimate empirical behavioral relationships, especially the behavior of the private sector of the Korean economy, we consider a open-loop Stackelberg strategy between the government and the private sector. An asymmetric Stackelberg strategy is highly probable because the government, in many circumstances, can play a leading role by announcing its policy designs or medium- and long-term economic plan. In such a case, the government is a Stackelberg leader, and producers and consumers act as followers. Since we have three decision makers in the game, the decision making order is assumed to be as follows : government (leader), producer (the first follower), and consumer (the last follower). Given the decision-making sequence, a representative consumer (the last follower) knows all the decisions that other players have chosen and hence forms his own Hamiltonian to determine his decision (reaction) vector $\mathbf{u}_c$ given the known government's and producer's decisions. Secondly, the producer forms his Hamiltonian given the known government's decision and determines his decision vector $\mathbf{u}_p$ taking into account the (correctly) expected consumer's reaction. Finally, the government as a leader controls its own policy vector $\mathbf{u}_g$ (government control) taking account of the expected followers' (consumer and producer) reactions in its optimization problem. In this way, the leader chooses his decision using his knowledge of the followers' decision criteria, and the followers make their decisions given the leader's decision. The dynamic game is played over the time interval $s \in (t, \infty)$, and all players have the vectors of piecewise continuous decision functions $\mathbf{u}_i$ (i = g, p, c), where g, p and c denote government, producer and consumer, respectively.

The government controls the policy variables $\mathbf{u}_g$ such as taxes and expenditures by optimizing its own objective taking account of the private sectors' best reactions in its

optimization. We assume that the government collects taxes on private consumption (at a proportional rate τ_1), profit (at a proportional rate τ_2), labor income (at a proportional rate τ_3), and imports (at a proportional rate τ_5). Another source of government revenue is to issue the government bond ($\dot{D}$) which is not a policy instrument but an accommodating means to finance the government deficit. The total government revenue (total tax revenue T, and bond issue $\dot{D}$) is spent on government consumption (G), government investment including adjustment costs, tax credit for private investment which includes adjustment costs (at a proportional rate τ_4), and interest payments on government debt. All these policy instruments except bond issue ($\dot{D}$) and interest payments are the elements of the vector $\mathbf{u}_g$. Additionally, government is assumed to control real wage (w).

The government's budget constraint in *per capita terms* can be written as (6.1) where μ denotes the population growth rate :

$$(6.1)\quad T_t + \dot{D}_t = G_t + \pi_t^k I_t^g \left(1+0.5\phi^g \frac{I_t^g}{K_t}\right) + \tau_4 \pi_t^k I_t^p \left(1+0.5\phi \frac{I_t^p}{K_t}\right) + (r - \mu)D_t$$

$$\text{or}\quad \dot{D}_t = G_t + \pi_t^k I_t^g \left(1+0.5\phi^g \frac{I_t^g}{K_t}\right) + \tau_4 \pi_t^k I_t^p \left(1+0.5\phi \frac{I_t^p}{K_t}\right) + (r - \mu)D_t$$

$$- [\ \tau_1 \pi_t^c C_t + \tau_2\{Q_t - (1+\tau_5)\pi_t^n N_t - w_t L_t\} + \tau_3 w_t L_t + \tau_5 \pi_t^n N_t\ ]$$

where all the variables except prices and ratios are in *per capita terms*. That is :

T = real total tax revenue $[\ \tau_1 \pi^c C + \tau_2\{Q - (1+\tau_5)\pi^n N - wL\} + \tau_3 wL + \tau_5 \pi^n N\ ]$.

$\dot{D}$ = real government bond issues (D is real government debt).

G = real government consumption.

P = the price of domestic goods.

π^c = domestic relative price of consumption goods in terms of the price of domestic goods $[P^c/P]$.

π^k = domestic relative price of capital goods in terms of the price of domestic goods $[P^k/P]$.

π^n = domestic relative price of imported intermediate inputs in terms of the price of domestic goods $[P^n/P]$

w = real wage rate in terms of the price of domestic goods.

$\pi^c C$ = real private consumption.

$\pi^k I^p$ = real private fixed investment.

$\pi^k I^g$ = real government fixed investment.

$\pi^n N$ = real imports of intermediate input.

wL = real total wage bill.

Q = real gross output.

K = real total capital stock.

τ_1 = consumption tax rate.

τ_2 = profit tax rate.

τ_3 = wage income tax rate.

τ_4 = investment tax credit rate.

τ_5 = tariff rate.

r = real interest rate on financial assets (i.e. internationally tradable bond B and government bond D).

μ = constant rate of growth of population.

ϕ = parameter for the private investment adjustment cost [$0.5\phi(I^p/K)$ is the adjustment cost per unit of physical private investment].

ϕ^g = parameter for the government investment adjustment cost [$0.5\phi^g(I^g/K)$ is the adjustment cost per unit of physical government investment].

Once the government decides and announces its decided policy actions $\mathbf{u}_g$ (τ_1, τ_2, τ_3, τ_4, τ_5, w, G, and I^g) after having taken into account the expected private sectors' reactions, the producer determines the time paths of his own decisions $\mathbf{u}_p$ (I^p, L, and N) after having taken into account the expected consumer's reaction and given the government policy actions. The consumer then determines his own decision $\mathbf{u}_c$ (only C) given all the other players' policy actions.

6.2.1 Consumer (the last follower)

The consumer decides his best policy to maximize his life-time utility ($\tilde{U}$) given the known decisions of the government and producer. Hence, the problem is to choose the time path of consumption expressed as (6.2) in *per capita terms* :

$$(6.2)\quad \underset{\{C_t\}}{\text{maximize}}\quad \tilde{U} = \int_t^{\infty} U(C_s)e^{-(\rho-\mu)(s-t)}ds$$

$$\text{subject to } \dot{A}_t = (r - \mu)A_t + (1-\tau_3)w_tL_t - (1+\tau_1)\pi_t^cC_t$$

where $A_t = B_t + D_t + V_t$ and ρ is the consumer's time preference rate. Note that consumer's income stream originates not only from labor income but also from non-human financial wealth (A), which is composed of net holdings of foreign assets (B), government bonds (D) and equity holdings equivalent to the market value of the firm (V).

The current-value Hamiltonian and the first order conditions of the consumer's problem are given as equations (6.3) ~ (6.5), where ψ is the shadow value of consumption :

$$(6.3)\quad H^C = U(C_t) + \psi_t\,[(r - \mu)A_t + (1-\tau_3)w_tL_t - (1+\tau_1)\pi_t^cC_t]$$

$$(6.4)\quad U'(C_t) = \psi_t(1+\tau_1)\pi_t^c \qquad [\text{from } \frac{\partial H^C}{\partial C_t} = 0]$$

$$(6.5)\quad \dot{\psi}_t = (\rho - r)\psi_t \qquad [\text{from } \dot{\psi}_t = (\rho - \mu)\psi_t - (\frac{\partial H^C}{\partial A_t})].$$

Together with the budget constraint in (6.2), the first order conditions above determine the best policy of the consumer, which we will discuss in more detail in section 6.5. Note that, since the consumer is the last follower in the multi-level Stackelberg game, he optimizes his objective function given all the other players' decisions. Therefore, the first order conditions for the consumer are the same as those derived from open-loop Nash strategy.

6.2.2 *Producer (the first follower)*

The producer, as already discussed, chooses his best reaction policy to maximize the market value of the firm (V) given the known government policy. Being the first follower, the producer should also take account of the expected consumer's reaction in the decision-making. Therefore, the problem of the producer is to choose his best policy on the demand for investment, labor, and imported input use (I^p, L, and N), and can also be expressed as (6.6) in *per capita terms* :

(6.6) $\underset{\{I_t^p\ L_t\ N_t\}}{\text{maximize}}$

$$V = \int_t^{\infty} [(1-\tau_2)\{Q(K_s,N_s,L_s)-(1+\tau_5)\pi_s^n N_s - w_s L_s\} - (1-\tau_4)\pi_s^k I_s^p (1+0.5\phi \frac{I_s^p}{K_s})] e^{-(\omega-\mu)(s-t)} ds$$

subject to $\dot{K}_t = I_t - (\delta+\mu)K_t$

where $K_t = K_t^p + K_t^g$

$I_t = I_t^p + I_t^g$

$K_0 = K_0^p + K_0^g$ are given.

The term ω is the producer's discount rate. The explicit form of the adjustment cost, $0.5\phi(I^p/K)$, per unit of physical private capital accumulation is in the tradition of adjustment cost models.[2] The ϕ is a constant parameter. For convenience, the open-loop Nash strategy will be considered first, followed by the Stackelberg case. In the case of a Nash strategy, the current-value Hamiltonian and the first order conditions are obtained as equations (6.7) ~ (6.9) :

$$(6.7)\quad H^P = (1-\tau_2)\{Q(K_t,N_t,L_t) - (1+\tau_5)\pi_t^n N_t - w_t L_t\} - (1-\tau_4)\pi_t^k I_t^p (1+ 0.5\phi \frac{I_t^p}{K_t}) + \lambda_t [I_t - (\delta+\mu)K_t]$$

$$(6.8)\quad \left(\frac{\partial H^P}{\partial \mathbf{u}_p}\right)_{3\times 1} = 0 \quad \left(\text{i.e. } \frac{\partial H^P}{\partial I_t^p} = \frac{\partial H^P}{\partial N_t} = \frac{\partial H^P}{\partial L_t} = 0\right)$$

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2 See, for example, Lipton and Sachs (1983) and Conway (1987).

$$(6.9)\quad \dot{\lambda}_t = (\omega-\mu)\lambda_t - \left(\frac{\partial H^P}{\partial K_t}\right)$$

where λ is the shadow price of newly installed capital and $\mathbf{u}_p$ is the vector of producer's control variables (I^P, N, and L).

However, in the case of a Stackelberg strategy with the given decision-making sequence assumed in this chapter, the producer takes account of the consumer's reaction in deciding his policy actions. Therefore, the first order conditions for the producer in the open-loop Stackelberg case are transformed to equations (6.8)' and (6.9)' which include additional terms to reflect the consumer's reaction characterized by the consumer's first order conditions :

$$(6.8)'\quad \left(\frac{\partial H^P}{\partial \mathbf{u}_p}\right)_{3\times1} + \left(\frac{\partial C_t}{\partial \mathbf{u}_p}\right)_{3\times1}\left(\frac{\partial H^P}{\partial C_t}\right)_{1\times1} = 0$$

$$(6.9)'\quad \dot{\lambda}_t = (\omega-\mu)\lambda_t - \left[\left(\frac{\partial H^P}{\partial K_t}\right) + \left(\frac{\partial C_t}{\partial K_t} + m\frac{\partial C_t}{\partial \psi_t}\right)\left(\frac{\partial H^P}{\partial C_t}\right)\right].$$

The term m in equation (6.9)' is taken as given by the producer, but is endogenous to the system by the relationship (6.10), where m is chosen so that the solution also satisfies the consumer's Euler equation (6.5) :

$$(6.10)\quad \psi_t = mA_t.$$

The relationship (6.10) is called the producer's 'time consistency' restriction.[3]

Rewriting equations (6.8)' and (6.9)', we obtain the following four equations of first order condition (6.11) ~ (6.14) for the producer :

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[3] Miller and Salmon (1985), citing Cohen and Michel (1984), argue that Bellman's Principle of Optimality in the open-loop Stackelberg game implies that the upper-level player (in our case, the producer) takes account of the lower-level player's behavior summarized in the first order condition [in our case, equation (6.4)], subject not to the lower-level player's Euler equation [in our case, equation (6.5)] but to the time consistency restriction [in our case, equation (6.10)].

(6.11) $Q_N(K_t,N_t,L_t) = (1+\tau_5)\pi_t^n$

(6.12) $Q_L(K_t,N_t,L_t) = w_t$

(6.13) $\lambda_t = (1-\tau_4)\pi_t^k(1+\phi\frac{I_t^p}{K_t})$

(6.14) $\dot{\lambda}_t = (\omega+\delta)\lambda_t - [(1-\tau_2)Q_K(K_t,N_t,L_t) + 0.5\phi(1-\tau_4)\pi_t^k(\frac{I_t^p}{K_t})^2]$.

Note that we can obtain the same first order conditions (6.11) ~ (6.14) from the Nash case [equations (6.8) ~ (6.9)]. This is because the term $(\partial H^P/\partial C_t)$ in the Stackelberg case [equations (6.8)' ~ (6.9)'] is zero which is obvious from equation (6.7). This shows that the production decision is made independently of consumption decision (the reverse is not true) under the given exogenous real rate of interest, real wage, and imported intermediate input price in an open economy. Hence, the resulting first order conditions in the Stackelberg case are the same as those in the Nash case. The condition (6.11) shows the static optimal condition for the use of imported intermediate input, (6.12) for the labor demand and (6.13) for the investment demand. The condition (6.14) is the dynamic (optimal) Euler equation which governs the time path of the shadow value of newly installed capital.

Note that the usual Tobin's q is obtained by dividing both sides of equation (6.13) by π_t^k, since π_t^k is now the replacement cost of the existing capital. If we divide the result by $(1-\tau_4)$ again, then the tax-adjusted Tobin's q is obtained. From equations (6.11) and (6.12), we can obtain the factor demand functions for the imported intermediate input and labor. The investment demand function can be obtained from equations (6.13) and (6.14). The detailed discussion of the estimable equations for the production system will be dealt with in a later section.

6.2.3 Government (leader)

As already mentioned, the government decides its policies to maximize its own objective (or social welfare) which is different from those of the private sectors. The problem now is to specify the objectives of government policy. In principle, the objectives of the government policy [4] could be those of stabilization, allocation, and redistribution. Since the establishment of the Economic Planning Board (EPB) in 1961, the main objectives of the Korean government, as embedded in the consecutive 5-year plans, have been : economic growth, full employment, and balance of payments equilibrium. In the 1980s, price stabilization and improvements in income distribution have been added.

Therefore, the problem of the government can be characterized, in *per capita terms*, as equation (6.15) :

$$(6.15)\quad \underset{\{\mathbf{u}_g\}}{\text{maximize}} \quad \int_t^{\infty} \Phi(F_s - T_s,\ G_s,\ I_s^g,\ B_s)e^{-(\vartheta-\mu)(s-t)}ds$$

$$\text{subject to} \quad \dot{K}_t = I_t - (\delta+\mu)\,K_t$$

$$\dot{D}_t = (r-\mu)D_t + G_t + \pi_t^k I_t^g(1+0.5\phi^g \frac{I_t^g}{K_t}) + \tau_4\pi_t^k I_t^p(1+0.5\phi \frac{I_t^p}{K_t}) - T_t$$

$$\text{where} \quad K_t = K_t^p + K_t^g$$

$$I_t = I_t^p + I_t^g$$

$$T_t = \tau_1\pi_t^c C_t + \tau_2\{Q_t - (1+\tau_5)\pi_t^n N_t - w_t L_t\} + \tau_3 w_t L_t + \tau_5\pi_t^n N_t$$

$$K_0,\ D_0 \text{ are given.}$$

The term ϑ is the discount rate of the government and $\mathbf{u}_g$ is the vector of government policy variables. The function Φ is the government's objective function which is positively related to the disposable income in private sector (F-T), government consumption (G), and government investment for development purposes (I^g).

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[4] For an extensive analysis of government behavior with regard to macroeconomic functioning, see van Velthoven (1989). Also Whang (1986) should be referred to for the detailed procedures of economic policy-making and implementation in Korea. He discusses the organizational structure of policy planning, and the process of implementation of planning, the review and monitoring of performance, and the feedback of monitored information in the decision-making process.

A preferred target level of the position of external assets (B) can also be an argument in the government objective function. Although we can specify an explicit form of quadratic utility function which ensures diminishing marginal utilities for each argument of the function, we will remain with the specification (6.15) since the estimation of the parameters of government utility function is not our purpose.

The current-value Hamiltonian resulting from equation (6.15) can be written as equation (6.16), where Ψ_1 and Ψ_2 denote the shadow prices of the respective government constraints :

$$(6.16)\quad H^G = \Phi(\cdot) + \Psi_1[I_t - (\delta+\mu)K_t] - \Psi_2[(r-\mu)D_t + G_t + \pi_t^k I_t^g(1+0.5\phi^g \frac{I_t^g}{K_t}) + \tau_4\pi_t^k I_t^p(1+0.5\phi \frac{I_t^p}{K_t}) - T_t].$$

Note that the second constraint $\dot{D}$ enters into the Hamiltonian with a negative sign since D is a debt (negative asset) of the government. In the case of the open-loop Nash strategy, the optimal policy design of the government is obtained from the usual optimization of the above Hamiltonian (6.16), under the assumption that the decisions of producer and consumer are known and given. The game is symmetric between the leader and the followers. Therefore, the first order conditions which determine the government's open-loop Nash strategy are characterized as (6.17), (6.18) and (6.19) :

$$(6.17)\quad (\frac{\partial H^G}{\partial \mathbf{u}_g})_{8\times1} = 0 \quad (\text{i.e. } \frac{\partial H^G}{\partial G} = \frac{\partial H^G}{\partial I^g} = \frac{\partial H^G}{\partial w} = \frac{\partial H^G}{\partial \tau_i} = 0, \quad i = 1, 2, 3, 4, 5)$$

$$(6.18)\quad \dot{\Psi}_1 = (\vartheta-\mu)\Psi_1 - (\frac{\partial H^G}{\partial K})$$

$$(6.19)\quad \dot{\Psi}_2 = (\vartheta-\mu)\Psi_2 + (\frac{\partial H^G}{\partial D})$$

where $\mathbf{u}_g$ is the vector of government's policy variables (G, I^g, w, τ_i for i= 1, 2, 3, 4, 5). The set of 8 equations (6.17) shows the static optimal conditions for the government.

Conditions (6.18) and (6.19) denote the dynamic Euler equations for the shadow value of the newly installed capital and income, respectively.

In the case of the open-loop Stackelberg strategy, however, the first order conditions of the government decision include additional terms which take into account the private sectors' reactions. Therefore, the first order conditions for the open-loop Stackelberg strategy of the government are transformed into equations (6.17)', (6.18)' and (6.19)':

$$(6.17)' \quad \left(\frac{\partial H^G}{\partial \mathbf{u}_g}\right)_{8\times1} + \left(\frac{\partial \mathbf{u}_j}{\partial \mathbf{u}_g}\right)_{8\times4}\left(\frac{\partial H^G}{\partial \mathbf{u}_j}\right)_{4\times1} = 0$$

$$(6.18)' \quad \dot{\Psi}_1 = (\vartheta-\mu)\Psi_1 - \left[\left(\frac{\partial H^G}{\partial K}\right) + \left(\frac{\partial \mathbf{u}_j}{\partial K} + n_1\frac{\partial \mathbf{u}_j}{\partial \Lambda}\right)_{1\times4}\left(\frac{\partial H^G}{\partial \mathbf{u}_j}\right)_{4\times1}\right]$$

$$(6.19)' \quad \dot{\Psi}_2 = (\vartheta-\mu)\Psi_2 + \left[\left(\frac{\partial H^G}{\partial D}\right) + \left(\frac{\partial \mathbf{u}_j}{\partial D} + n_2\frac{\partial \mathbf{u}_j}{\partial \Lambda}\right)_{1\times4}\left(\frac{\partial H^G}{\partial \mathbf{u}_j}\right)_{4\times1}\right].$$

The term $\mathbf{u}_j$ is the vector of private sectors' policy variables altogether (C, I^p, L, N), and n_i (i = 1, 2) is the row vector of the matrix $n_{(2\times2)}$ which is taken as given by the government (Stackelberg leader) but is endogenous to the system by the time consistency restriction (6.20) :

$$(6.20) \quad \Lambda = n\Theta, \qquad \text{where } \Lambda = \begin{bmatrix} \psi \\ \lambda \end{bmatrix}, \qquad \Theta = \begin{bmatrix} A \\ K \end{bmatrix}.$$

Θ and Λ are the column vectors of the private sector's state variables (A, K) and their shadow values (ψ,λ), respectively. The relationship (6.20) also satisfies the private sectors' Euler equations (6.5) and (6.14).

6.2.4 Market Clearing and Equilibrium

Under the exogenously given world real interest rates, imported input price and real wage, the production decision is shown to be made independently of the

consumption decision, even though we assume an open-loop Stackelberg game with the decision-making sequence of government → producer → consumer. Therefore, the private sectors' equilibrium is characterized by the optimal conditions (6.4) ~ (6.5) and (6.11) ~ (6.14) together with the budget constraints implicitly included in (6.2) and (6.6). The optimal decision of the government is governed by the optimal conditions (6.17)', (6.18)' and (6.19)' together with the budget constraints contained in (6.15). The resulting Stackelberg equilibrium for the whole economy is determined by the strategic interaction between the government decision and the private sectors' decisions governed by the respective optimal conditions described above. If we assume quadratic objective functions for government, producer and consumer, the optimal reaction functions of the three actors can be solved for analytically using the methods described in the literature [e.g. Miller and Salmon (1985) and Oudiz and Sachs (1985)].[5]

Additionally, the market clearing conditions for goods and assets (tradable foreign assets and domestic government bonds), under the assumption that the exogenous real interest rate equals the discount rates of the three actors, can be integrated into the economy's current account equation (6.21) :

$$(6.21)\quad \dot{B}_t = \dot{A}_t - \dot{D}_t - \dot{V}_t = (r-\mu)B_t + Q(K_t, N_t, L_t) - \pi_t^n N_t - \pi_t^c C_t - G_t - \pi_t^k TI_t$$

where $\dot{D}_t$ and $\dot{A}_t$ are given by equations (6.1) and (6.2), respectively, and $\dot{V}_t$ can be obtained by differentiating V in equation (6.6) with respect to time. $\pi^k TI$ is the total investment expenditure including the adjustment costs. Note, again, that the resulting current account expression is the gap between saving and investment as in the previous chapters.

In the following sections, we will derive estimable stochastic equations for all endogenous reaction (decision) functions from the optimal conditions derived earlier. Then the stochastic decision functions will be estimated using the Korean data. The main reason for choosing the estimation approach is that, in the real world of uncertainty, the

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5 For the numerical algorithm and computer software for the two-point boundary-value problems, see Press et al. (1986), pp. 578 -614, and Lipton et al. (1982) for a multiple-shooting algorithm.

agents' decisions [$\mathbf{u}_i(s)$ for $s \in (t, \infty)$] are not likely to be carried throughout the whole planning period without any change. If, unlike the perfect foresight certainty case, new information becomes available at time t, the optimal decisions will be recalculated for the period t+1 onwards with current decisions unaffected. Therefore, the observed data for the endogenous decision variables can be thought of as only the first period of each optimal decisions carried out, since new information could arise every period. For the purpose of empirical analysis, the assumption of rational expectations about the uncertain future variables is introduced from the following section.

6.3 Estimation of Production and Factor Demand Decisions

6.3.1 Derivation of Estimable Equations

Since the producer's objective was assumed to be maximizing the market value of the firm, the gross output and factor demands are endogenous. Therefore, the relevant production system consists not only of the output function but also of the first order conditions for the maximization of the firm's market value [see equations (6.11) ~ (6.14)]. In order to apply the above production system to Korean economic data, we need a specific functional form of the production function which can be a reasonable approximation of the production technology. Conventionally, the Cobb-Douglas or Constant (or Variable) Elasticity of Substitution function have been widely used for estimation purposes.[6] However, it is well known that the restrictions imposed by these functional forms are frequently rejected by the data. The Cobb-Douglas form restricts all elasticities of substitution between inputs to be unity, and the CES form restricts pairwise elasticities of substitution to be constant and equal for all input levels.

In this section, therefore, we adopt the Transcendental Logarithmic (Translog, for short) functional form, which is more general and flexible. In the Translog functional form, the logarithm of output is a function of the logarithms of the individual inputs, the squares of the logarithms of inputs, and interaction terms between the pairwise

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6 For the Korean case, Park and Lee (1986) try to apply several forms of CES and VES production functions suggested in the existing literature. However, they found that it was difficult to find a stable relationship among production (manufacturing and business sector), labor, and capital in Korea.

logarithms of factors. Hence, the three input (L,N,K) Translog function with symmetry condition $b_{ij} = b_{ji}$ (i, j = L,N,K) can be expressed as (6.22) :

$$(6.22)\quad ln\,Q = a_0 + a_L\,ln\,L + a_N\,ln\,N + a_K\,ln\,K + \frac{1}{2}b_{LL}(ln\,L)^2 + \frac{1}{2}b_{NN}(ln\,N)^2 + \frac{1}{2}b_{KK}(ln\,K)^2 + b_{LN}(ln\,L)(ln\,N) + b_{LK}(ln\,L)(ln\,K) + b_{NK}(ln\,N)(ln\,K) + \varepsilon_Q$$

where Q is gross output, L is labor input, N is imported intermediate input, and K is capital stock. The term ε_Q is the stochastic error term. Estimation of equation (6.22) by Ordinary Least Squares (OLS) will result in inconsistent estimates of the parameters since endogenous factor demand variables are included on the right-hand side of the equation. This problem can be overcome by a system estimation approach. Differentiating the Translog function logarithmically with respect to the three inputs, we can obtain three input elasticity equations of output, which turn into factor share equations if the first order conditions of the firm's optimization problem, (6.11) ~ (6.14), are inserted. The three factor (cost) share equations are obtained as (6.23) :

$$(6.23a)\quad S_L = \frac{\partial ln\,Q}{\partial ln\,L} = Q_L(\frac{L}{Q}) = a_L + b_{LL}\,ln\,L + b_{LN}\,ln\,N + b_{LK}\,ln\,K + \varepsilon_L$$

$$(6.23b)\quad S_N = \frac{\partial ln\,Q}{\partial ln\,N} = Q_N(\frac{N}{Q}) = a_N + b_{LN}\,ln\,L + b_{NN}\,ln\,N + b_{NK}\,ln\,K + \varepsilon_N$$

$$(6.23c)\quad S_K = \frac{\partial ln\,Q}{\partial ln\,K} = Q_K(\frac{K}{Q}) = a_K + b_{LK}\,ln\,L + b_{NK}\,ln\,N + b_{KK}\,ln\,K + \varepsilon_K$$

where ε_i (i = L, N, K) denotes the stochastic disturbance term for the respective factor share equation.

Before estimating this production system, we impose the constant returns to scale (CRS) condition. Thus, the symmetry and constant returns to scale conditions are given as (6.24) :

(6.24) $b_{ij} = b_{ji}, \quad \sum_i a_i = 1, \quad \sum_i b_{ij} = 0 \ (\text{ or } \sum_j b_{ij} = 0), \quad \text{where } i, j = L,N,K.$

Note that one of the equations (6.23) needs to be eliminated to obtain a non-singular production system since the three factor share equations are dependent under the symmetry-constant returns to scale restriction.[7] The estimates obtained are invariant to which equation is eliminated, so the capital share equation is eliminated.

The resulting stochastic equations for gross output and factor shares from which factor demand equations can be obtained by inserting the producer's first order conditions, are given as equations (6.25). Since the data we are using are seasonally unadjusted quarterly data, three seasonal dummies D_i (i=1,2,3) are included in each equation :

$$(6.25a)\quad ln\left(\frac{Q}{K}\right)_t = a_0 + a_L ln\left(\frac{L}{K}\right)_t + a_N ln\left(\frac{N}{K}\right)_t + \frac{1}{2}\left[b_{LL}\left(ln\left(\frac{L}{K}\right)_t\right)^2 + b_{NN}\left(ln\left(\frac{N}{K}\right)_t\right)^2\right]$$

$$+ b_{LN} ln\left(\frac{L}{K}\right)_t ln\left(\frac{N}{K}\right)_t + \sum_{i=1}^{3} d_i^Q D_{it} + \varepsilon_{t,Q}$$

$$(6.25b)\quad S_{t,L} = \left(\frac{wL}{Q}\right)_t = a_L + b_{LL} ln\left(\frac{L}{K}\right)_t + b_{LN} ln\left(\frac{N}{K}\right)_t + \sum_{i=1}^{3} d_i^L D_{it} + \varepsilon_{t,L}$$

$$(6.25c)\quad S_{t,N} = \left(\frac{(1+\tau_5)\pi^n N}{Q}\right)_t = a_N + b_{LN} ln\left(\frac{L}{K}\right)_t + b_{NN} ln\left(\frac{N}{K}\right)_t + \sum_{i=1}^{3} d_i^N D_{it} + \varepsilon_{t,N}.$$

Now the objective is to obtain consistent and efficient estimates of the parameters. Since the cross-equation symmetry-CRS restrictions are imposed on the system (6.25), single-equation method of estimation such as OLS or Two-Stage Least Squares (2SLS) cannot be used. One of the widely used estimation procedures for systems with cross-equation restrictions is iterative Seemingly Unrelated Regression (SUR), since SUR

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[7] Berndt and Christensen (1973) estimate (n-1) factor share equations without including production. In that case, however, the constant term a_0 cannot be obtained. Alternatively, Kalirajan (1990) estimates n factor share equations and the production function simultaneously with only symmetry constraints.

parameter estimates are invariant to the equation eliminated by the imposed symmetry-CRS restriction. However, the estimation of the system (6.25) by SUR is still subject to the simultaneity bias because some of the explanatory variables are endogenous variables. For this reason we have chosen the iterative Three-Stage Least Squares (3SLS) which gives consistent and asymptotically efficient parameter estimates which are invariant to the choice of equations. The iterative 3SLS estimator is asymptotically equivalent to the Full Information Maximum Likelihood (FIML) estimator.[8]

6.3.2 Estimation

Quarterly seasonally unadjusted Korean data are used in the estimation of system (6.25) for the period 1972 ~ 1987. The required data are the prices (tariff or tax inclusive) and quantities of the services of three inputs, and the gross output. A detailed discussion of the data is attached in the appendix to this chapter. Since the data are quarterly time series, we included seasonal dummies to capture the seasonality in estimating the system. The iterative 3SLS estimates of the gross output and factor share equations are summarized in Table 6.1. The instruments for the system estimation are w_{t-i} (i = 0 ~ 3), $[(1+\tau_5)\pi^n]_{t-i}$ (i = 0 ~ 3), $ln\ K_{t-i}$ (i = 0 ~ 3), $ln\ L_{t-i}$ (i = 1 ~ 3), $ln\ N_{t-i}$ (i = 1 ~ 3), time trend, a constant, and seasonal dummies (D1, D2, D3). The starting values for all the parameters are set as zeros.

The R-squared and asymptotic t-statistics show that the Translog production system fits the data reasonably well. Since the D.W. statistic is not a valid test for serial independence in simultaneous systems, the residual analysis for system methods suggested by Breusch and Godfrey (1981) and Pagan and Hall (1983) was used to test for serial correlation. The procedure is to test $H_0 : c_{QQ} = c_{QL} = c_{QN} = c_{LQ} = c_{LL} = c_{LN} = c_{NQ} = c_{NL} = c_{NN} = 0$, when the alternative system is the following augmented version of the original system (6.26) :

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8 See Dhrymes (1973) for the relationship between the 3SLS and FIML estimators.

$$(6.26a)\quad ln\left(\frac{Q}{K}\right)_t = a_0 + a_L ln\left(\frac{L}{K}\right)_t + a_N ln\left(\frac{N}{K}\right)_t + \frac{1}{2}\left[b_{LL}\left(ln\left(\frac{L}{K}\right)_t\right)^2 + b_{NN}\left(ln\left(\frac{N}{K}\right)_t\right)^2\right]$$

$$+ b_{LN} ln\left(\frac{L}{K}\right)_t ln\left(\frac{N}{K}\right)_t + \sum_{i=1}^{3} d_i^Q D_{it} + c_{QQ}\hat{\varepsilon}_{t-p,Q} + c_{QL}\hat{\varepsilon}_{t-p,L} + c_{QN}\hat{\varepsilon}_{t-p,N} + \eta_Q$$

$$(6.26b)\quad S_{t,L} = a_L + b_{LL} ln\left(\frac{L}{K}\right)_t + b_{LN} ln\left(\frac{N}{K}\right)_t + \sum_{i=1}^{3} d_i^L D_{it} + c_{LQ}\hat{\varepsilon}_{t-p,Q} + c_{LL}\hat{\varepsilon}_{t-p,L} + c_{LN}\hat{\varepsilon}_{t-p,N}$$

$$+ \eta_L$$

$$(6.26c)\quad S_{t,N} = a_N + b_{LN} ln\left(\frac{L}{K}\right)_t + b_{NN} ln\left(\frac{N}{K}\right)_t + \sum_{i=1}^{3} d_i^N D_{it} + c_{NQ}\hat{\varepsilon}_{t-p,Q} + c_{NL}\hat{\varepsilon}_{t-p,L} + c_{NN}\hat{\varepsilon}_{t-p,N}$$

$$+ \eta_N$$

where the $\hat{\varepsilon}_{t-p,i}$ (i = Q, L, N) are the p-th lagged values of the residuals obtained from estimating the original system by 3SLS. Therefore, if the alternative system (6.26) is estimated by 3SLS, the H_0 can be tested by the quasi-likelihood ratio (QLR) test proposed by Amemiya (1977) and Gallant and Jorgenson (1979). The general (non-linear) 3SLS estimates of parameters ($\mathbf{b}_3$) are obtained by minimizing the distance function $S(\mathbf{b}_3) = (\frac{1}{T})g(\mathbf{b}_3)'(\hat{\Sigma}^{-1}\otimes P_Z)g(\mathbf{b}_3)$, where T is the number of observations, $g(\mathbf{b}_3)$ is the stacked vector of residuals from the model, $\hat{\Sigma}$ is a consistent estimate of the residual covariance, and P_Z is a projection matrix of the instruments $Z(Z'Z)^{-1}Z'$. The QLR test for 3SLS defined by $T[S(\mathbf{b}_3)_0 - S(\mathbf{b}_3)_1]$ is distributed asymptotically as a chi-square with degrees of freedom equal to the number of restrictions imposed. $S(\mathbf{b}_3)_0$ is the minimum distance function for the null hypothesis, and $S(\mathbf{b}_3)_1$ for the alternative hypothesis. The resulting QLR statistics indicate the null hypothesis of no serial correlation is rejected in the case of p=1, but not in the case of p=4.[9] This result is not at all surprising if we consider the fact that firms in general cannot react instantly to the changed economic environment, but take time to adjust their decisions in production and factor demand.

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[9] The one period lagged and four period lagged residuals $\hat{\varepsilon}_{t-1,i}$, $\hat{\varepsilon}_{t-4,i}$ (i=Q,L,N) are added to the original set of instruments when we test serial correlation for p=1 and p=4, respectively.

Table 6.1

3SLS Estimates of Translog Gross Output and Input Functions with Symmetry-CRS Restriction in Korea : 1972.I ~ 1987.IV [a]

Parameter	*ln* (Q/K)	S_L	S_N
a_0	- 1.2463 (- 24.400)		
a_L	0.2676 (14.987)	0.2676 (14.987)	
a_N	0.4481 (19.789)		0.4481 (19.789)
a_K [b]	0.2843[b] (10.983)[b]		
b_{LL}	- 0.0266 (- 4.664)	- 0.0266 (- 4.664)	
b_{LN}	- 0.0353 (- 11.567)	- 0.0353 (- 11.567)	- 0.0353 (- 11.567)
b_{LK} [b]	0.0618[b] (9.513)[b]	0.0618[b] (9.513)[b]	
b_{NN}	0.0584 (9.513)		0.0584 (9.513)
b_{NK} [b]	- 0.0231[b] (- 3.371)[b]		- 0.0231[b] (- 3.371)[b]
b_{KK} [b]	- 0.0387[b] (- 2.899)[b]		
d_1^j (j= Q,L,N)	- 0.4312 (- 21.202)	- 0.0276 (- 3.833)	0.0690 (16.152)
d_2^j (j= Q,L,N)	- 0.3472 (- 17.161)	- 0.0156 (- 2.151)	0.0549 (12.673)
d_3^j (j= Q,L,N)	- 0.3119 (- 15.349)	- 0.0159 (- 2.204)	0.0431 (10.061)
R^2	0.9396	0.7081	0.8884
S. E. of Regression	0.0634	0.0109	0.0119
Standard Deviation	0.2382	0.0195	0.0351

QLR Test for Serial Correlation :	Test Statistic	Critical Value
p=1 (one period lagged residuals)	25.06	$\chi^2_{0.01}(9)=21.67$
p=4 (four period lagged residuals)	5.72	$\chi^2_{0.01}(9)=21.67$

Notes : a Convergence achieved after 1 iteration since the system is linear in the parameters, and the number of observations is 64. Asymptotic t-statistics are in parentheses.

b Parameters are recovered from the symmetry-constant returns to scale restriction [eq.(6.24) in the text]. The t-statistics of this parameters are calculated from the covariance matrix of the estimated system.

Any production or factor demand function without a lagged adjustment mechanism posits a simultaneous long-run adjustment of inputs to changes in input price and technology. This assumption is particularly unrealistic when the function is estimated from quarterly time-series data. Therefore, the more realistic specification of the production system may be a first-order dynamic system rather than a static one since the estimated system (6.25) shows evidence of first-order serial correlation. A useful way of handling this problem is to transform the original system (6.25) into a dynamic system which may have serially independent errors. The simplest way of constructing a dynamic system is to construct an AR(1) process. Firstly, since strong evidence of first-order serial correlation is found, each equation of the system is lagged by one period and multiplied through by the autocorrelation coefficient ρ_i (i = Q, L, N). Secondly, each of the above lagged equations is subtracted from each of the original equations.

The resulting first-order dynamic system is given as equations (6.27) which can be regarded as a convenient simplification of a more general dynamic system in the sense that it reduces the number of parameters to be estimated from 27 to 18. Therefore, the introduction of the following autoregressive error process as (6.27) can be used to simplify the dynamic specification if the assumed parameter restrictions of the AR (1) process are not rejected by the data :

$$\text{(6.27a)}\ ln\left(\frac{Q}{K}\right)_t = a_0(1-\rho_Q) + a_L[ln\left(\frac{L}{K}\right)_t - \rho_Q ln\left(\frac{L}{K}\right)_{t-1}] + a_N[ln\left(\frac{N}{K}\right)_t - \rho_Q ln\left(\frac{N}{K}\right)_{t-1}]$$

$$+ \frac{1}{2} b_{LL}[(ln\left(\frac{L}{K}\right)_t)^2 - \rho_Q(ln\left(\frac{L}{K}\right)_{t-1})^2] + \frac{1}{2} b_{NN}[(ln\left(\frac{N}{K}\right)_t)^2 - \rho_Q(ln\left(\frac{N}{K}\right)_{t-1})^2]$$

$$+ b_{LN}[ln\left(\frac{L}{K}\right)_t ln\left(\frac{N}{K}\right)_t - \rho_Q ln\left(\frac{L}{K}\right)_{t-1} ln\left(\frac{N}{K}\right)_{t-1}] + \rho_Q ln\left(\frac{Q}{K}\right)_{t-1} + \sum_{i=1}^{3} d_i^Q D_{it} + \zeta_Q$$

$$\text{(6.27b)}\ S_{t,L} = a_L(1-\rho_L) + b_{LL}[ln\left(\frac{L}{K}\right)_t - \rho_L ln\left(\frac{L}{K}\right)_{t-1})] + b_{LN}[ln\left(\frac{N}{K}\right)_t - \rho_L ln\left(\frac{N}{K}\right)_{t-1})]$$

$$+ \rho_L S_{t-1,L} + \sum_{i=1}^{3} d_i^L D_{it} + \zeta_L$$

$$(6.27c)\quad S_{t,N} = a_N(1-\rho_N) + b_{LN}[ln\,(\frac{L}{K})_t - \rho_N ln\,(\frac{L}{K})_{t-1}] + b_{NN}[ln\,(\frac{N}{K})_t - \rho_N ln\,(\frac{N}{K})_{t-1}] + \rho_N S_{t-1,N} + \sum_{i=1}^{3} d_i^N D_{it} + \zeta_N$$

where ζ_i (i = Q, L, N) are the new serially uncorrelated error processes. Since the ρ_i are unknown and the dynamic system involves non-linear parameter restrictions on the right-hand side, the dynamic system was estimated by general Non-Linear Three-Stage Least Squares (NL3SLS) with the non-linear parameter restrictions. The same set of instruments as the original system (6.25) was used and the initial values for all the parameters were set as zeros. The QLR-test statistic for the non-linear parameter restriction of the AR (1) process against the first-order dynamic system was 5.55, which indicates we can accept the parameter restrictions both at 5% and 1% levels [critical values : $\chi^2_{0.05}(9) = 16.92$, $\chi^2_{0.01}(9) = 21.67$]. The estimation results of AR(1) process are reported in Table 6.2. The simplified dynamic specification of the production system has eliminated the serial correlation. As shown in Table 6.2 there is no evidence of serial correlation.[10]

We also checked if the estimated Translog production function is well-behaved in both the static and dynamic cases, since the Translog function does not satisfy the conditions for the well-behaved production function globally. This test can be done by checking the monotonicity and quasi-concavity of the estimated gross output function. It turned out that all the fitted factor shares are positive for all observations, which means the monotonicity conditions are satisfied (Q_L, Q_N, $Q_K > 0$). Also the Hessian determinant bordered by the first order derivatives of the estimated Q function, $|\bar{Q}|$, was negative definite (the bordered principal minors of the $|\bar{Q}|$ have alternate signs starting from negative, $|\bar{Q}_1| < 0$, $|\bar{Q}_2| > 0$, $|\bar{Q}_3| < 0$) for all the sample observations, which proves the quasi-concavity of the estimated gross output function. Q_{ij} (i,j = L,N,K) was positive for $i \neq j$, and negative for $i = j$. The positive cross partial derivatives of the

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10 The one period lagged and four period lagged estimated residuals $\hat{\zeta}_{t-1,i}$, $\hat{\zeta}_{t-4,i}$ (i=Q,L,N) are added to the original set of instruments when we test serial correlations for one period lagged residuals and four period lagged residuals, respectively.

Table 6.2

NL3SLS Estimates of Translog Gross Output and Input Functions with AR(1) Process in Korea : 1972.I ~ 1987.IV [a]

Parameter	*ln* (Q/K)	S_L	S_N
a_0	- 1.6333 (- 11.219)		
a_L	0.4443 (8.799)	0.4540 (8.844)	
a_N	0.3885 (8.553)		0.3499 (7.709)
a_K [b]	0.1672[b] (2.960)[b]		
b_{LL}	- 0.0546 (- 3.688)	- 0.0522 (- 3.510)	
b_{LN}	- 0.0219 (- 3.231)	- 0.0187 (- 2.744)	- 0.0187 (- 2.744)
b_{LK} [b]	0.0765[b] (5.044)[b]	0.0710[b] (4.678)[b]	
b_{NN}	0.0695 (5.515)		0.0627 (4.875)
b_{NK} [b]	- 0.0475[b] (- 3.136)[b]		- 0.0440[b] (- 2.840)[b]
b_{KK} [b]	- 0.0290[b] (- 0.957)[b]		
ρ_i (i=Q,L,N)	0.2714 (2.343)	0.9558 (22.518)	0.6079 (6.609)
d_1^j (j= Q,L,N)	- 0.5327 (- 12.272)	- 0.0220 (- 5.635)	0.0944 (18.016)
d_2^j (j= Q,L,N)	- 0.3264 (- 13.275)	0.0106 (1.972)	0.0338 (5.672)
d_3^j (j= Q,L,N)	- 0.3146 (- 15.900)	- 0.0043 (- 1.605)	0.0345 (7.986)
R^2	0.9401	0.9570	0.9181
S. E. of Regression	0.0582	0.0041	0.0101
Standard Deviation	0.2382	0.0195	0.0351

QLR Test for Serial Correlation :	Test Statistic	Critical Value
one period lagged residuals	2.73	$\chi^2_{0.01}(9)=21.67$
four period lagged residuals	20.88	$\chi^2_{0.01}(9)=21.67$

Notes : a Convergence achieved after 8 iterations, and the number of observations is 64. Asymptotic t-statistics are in parentheses.

b Parameters are recovered from the symmetry-constant returns to scale restriction [eq.(6.24) in the text]. The t-statistics of these parameters are calculated from the covariance matrix of the estimated system.

estimated gross output function ($Q_{ij} > 0$) indicates that the three factors are pairwise cooperative in production.[11] Therefore, the estimated production system is well-behaved throughout the sample period. Moreover, the dynamic production system fits the actual Korean data reasonably well.

6.3.3 Elasticity of Substitution and Some Implications

To investigate the factor substitution possibilities in the case of three factors of production, the Allen's *partial elasticity of substitution* (σ_{ij}) was computed based on the estimated production system. The definition of the partial elasticity of substitution is :[12]

$$(6.28) \quad \sigma_{ij} = \left[\frac{(\frac{\partial Q}{\partial X_1})X_1 + (\frac{\partial Q}{\partial X_2})X_2 + \cdots + (\frac{\partial Q}{\partial X_n})X_n}{X_i X_j} \right] \frac{|\bar{Q}_{ij}|}{|\bar{Q}|}$$

where $|\bar{Q}|$ is the Hessian bordered by the first-order derivatives of the gross output Q, and $|\bar{Q}_{ij}|$ is the cofactor of the element Q_{ij} in the bordered Hessian. Although the definition of the elasticity includes input level terms such as X_i (or X_j), it ends up as a function of only the estimated parameters (b_{ij}) and the estimated factor shares (S_i) if we substitute the three-factor bordered Hessian into the formula (6.28). Therefore, the estimates of the σ_{ij} are independent of the units of measurement of the data. The results are given in Table 6.3.

The numbers reported in Table 6.3 are the quarterly averages of the estimated elasticities for each year. A positive sign denotes that the two factor inputs are substitutes. Several interesting findings are in order : (1) Overall, all the three factors are

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11 The definition of cooperation is different from the usual definitions of complementarity or substitutability in production. Factors can be Hicksian substitutes and yet cooperative. See Berndt and Wood (1979) for a detailed discussion.

12 See Allen (1938), pp. 503-509 for the definition of the partial elasticity of substitution. See also Uzawa (1988), pp. 93-95.

Table 6.3

Allen's Partial Elasticity of Substitution between Labor, Capital and Imported Intermediate Input in Korea : Quarterly Average, 1972 ~ 1987
(calculation on the basis of NL3SLS estimates)

Year	σ_{NL}	σ_{NK}	σ_{LK}
1972	0.047	0.084	0.119
1973	0.049	0.089	0.116
1974	0.046	0.091	0.114
1975	0.048	0.096	0.113
1976	0.053	0.102	0.109
1977	0.061	0.107	0.106
1978	0.067	0.106	0.106
1979	0.070	0.101	0.109
1980	0.067	0.091	0.118
1981	0.068	0.096	0.113
1982	0.068	0.094	0.115
1983	0.069	0.090	0.118
1984	0.070	0.093	0.115
1985	0.069	0.091	0.117
1986	0.070	0.095	0.114
1987	0.072	0.095	0.112
Mean	0.062	0.095	0.113

pairwise substitutes,[13] and the degrees of substitutability are relatively low judging from the estimated magnitudes of the elasticities. (2) Labor and capital are substitutes for each other. The elasticity of substitution between labor and capital (σ_{LK}) was 0.125 on average for the sample period. (3) The imported intermediate input was found to be a weak substitute to both labor (σ_{NL} = 0.060, on average) and capital(σ_{NK} = 0.091, on average). (4) Relatively stable figures of the elasticities over the sample period indicate that the structure of the production relationship has not changed very much over the period.

[13] To the best of my knowledge, there has not been any previous empirical study on the substitution possibilities among labor, capital and imported intermediate input in Korea. Empirical evidence on the substitution possibilities of energy, capital, and labor for other industrial countries are ample. For example, see Griffin and Gregory (1976) where energy, capital and labor are shown to be substitutes between each pairs for 9-OECD countries from cross-country analysis. On the contrary, Berndt and Wood (1975) show that energy and capital are complements for each other on the basis of a time-series analysis on U.S. manufacturing.

Now we can derive some provisional policy implications from the empirical results of the production side of the Korean economy. Since the imported intermediate input is a very weak substitute for both labor and capital, judging from the size of each elasticity, we can expect that the adjustment of the economy to higher import price of intermediate input will be somewhat sluggish on the production side. This result is quite plausible if we take into account the fact that the Korean economy is highly dependent upon imported intermediate materials in production. Of course, the more complete picture of the economic policy implications should be reserved until we analyze the expenditure and government sides of the economy.

6.4 Investment Decision and Expectations

6.4.1 Derivation of Estimable Equation

The estimable equation for private investment can be obtained from the optimal conditions and the Euler equation of the producer. The condition (6.13) shows the static optimal condition that investment continue until its marginal cost equals its marginal benefit. From this equation, the investment can be shown to be an increasing function of Tobin's q (tax-adjusted) which is the relative price of newly installed capital to uninstalled capital :

$$(6.29)\quad \frac{I_t^p}{K_t} = \frac{1}{\phi}\left[\frac{\lambda_t}{(1-\tau_4)\pi_t^k} - 1\right] + \upsilon_t = \frac{1}{\phi}(q_t-1) + \upsilon_t$$

where the stochastic error term υ_t is included because we relax the perfect foresight assumption.

In order to estimate the investment equation, we need some measures for λ or q. The measure of λ (or q) can be obtained from the Euler equation (6.14) which shows the dynamic optimal condition that the capital gain is the difference between the required

return and the marginal rentals from an additional physical unit of capital in the long run.[14] By integrating the equation (6.14) and using the transversality condition of the producer, $\lim_{s\to\infty} e^{-(\omega+\delta)(s-t)}\lambda_s = 0$, we can show that the shadow value λ is the present value of all the current and future after-tax marginal rentals including some adjustment costs as in equation (6.30) :

$$(6.30)\quad \lambda_t = E_t\int_t^{\infty}[(1-\tau_2)\frac{\partial Q_s}{\partial K_s} + 0.5\phi(1-\tau_4)\pi_s^k(\frac{I_s^p}{K_s})^2]e^{-(\omega+\delta)(s-t)}ds$$

$$\simeq E_t\sum_{i=0}^{\infty}[(1-\tau_2)(\frac{\partial Q}{\partial K})_{t+i} + 0.5\phi(1-\tau_4)\pi_{t+i}^k(\frac{I^p}{K})_{t+i}^2](1+\omega+\delta)^{-i}$$

$$= \sum_{i=0}^{\infty}x_{t+i}^t R_1^i = x_t^t + R_1\lambda_{t+1}^t$$

where E_t denotes the expectation for the future variables as of time t. The second line of equation (6.30) is the discrete time version which is more convenient for the empirical analysis. If we let $R_1 = \frac{1}{(1+\omega+\delta)}$, $Y_t = \frac{I_t^p}{K_t}$, $p_t = (1-\tau_4)\pi_t^k$, $z_t = (1-\tau_2)(\frac{\partial Q_t}{\partial K_t})$, and $x_t = z_t + 0.5\phi p_t Y_t^2$ for notational convenience, the expression simplifies to the third line where superscript t replaces E_t of the above lines. Then, by substituting equation (6.30) into (6.29), we can easily obtain the investment equation (6.31) where λ or q is eliminated :

$$(6.31)\quad Y_t = -\frac{1}{\phi} + \frac{1}{\phi p_t}[x_t + R_1 x_{t+1}^t + R_1^2 x_{t+2}^t + \cdots\cdots] + \upsilon_t .$$

However, equation (6.31) is not yet ready for estimation because it includes the variables involving expectations conditional on information at time t (x_{t+k}^t) which cannot

[14] There are some examples which estimate the parameters of the agent's decision variable by exploiting the Euler equation of the agent's optimization. This procedure typically involves variables with future expectations. See Pesaran (1987) for an extensive discussion of the technical aspects and examples. See also Abel (1980) for an example of an empirical investment model.

be observable, even *ex post*. If we assume rational expectations for x^t_{t+k}, then we have equation (6.32), where ξ_{t+k} is the error in the expectation of x_{t+k} :

$$(6.32) \quad x_{t+k} = x^t_{t+k} + \xi_{t+k} = E(x_{t+k} \mid \Omega_t) + \xi_{t+k}, \quad k = 1, 2, \ldots \ .$$

The errors of expectations conditional on the information set available at time t (Ω_t) have zero mean [i.e. $E(\xi_{t+k} \mid \Omega_t) = 0$]. Using the assumption of rational expectations (6.32) and applying the standard Koyck transformation to the geometric lead equation by subtracting $R_1 \frac{p_{t+1}}{p_t} Y_{t+1}$ from both sides of (6.31), we obtain equation (6.33) :

$$(6.33) \quad Y_t = R_1 \frac{p_{t+1}}{p_t} Y_{t+1} + \frac{x_t}{\phi p_t} + \frac{1}{\phi}(R_1 \frac{p_{t+1}}{p_t} - 1) + \frac{1}{\phi p_t} \sum_{k=1}^{\infty} (x^t_{t+k} - x^{t+1}_{t+k}) R_1^k$$
$$+ (\upsilon_t - R_1 \frac{p_{t+1}}{p_t} \upsilon_{t+1})$$
$$= R_1 \frac{p_{t+1}}{p_t} Y_{t+1} + \frac{1}{\phi}(\frac{z_t}{p_t} + 0.5\phi Y_t^2) + \frac{1}{\phi}(R_1 \frac{p_{t+1}}{p_t} - 1)$$
$$+ \frac{1}{\phi p_t} \sum_{k=1}^{\infty} (x^t_{t+k} - x^{t+1}_{t+k}) R_1^k + (\upsilon_t - R_1 \frac{p_{t+1}}{p_t} \upsilon_{t+1}) \ .$$

Another point to note is that we cannot observe the investment volume I^p_t net of adjustment (installation) costs and hence $Y_t = I^p_t / K_t$. What we observe is the real private investment which includes the installation costs [i.e. $\pi^k_t IP_t = \pi^k_t I^p_t (1+0.5\phi \frac{I^p_t}{K_t})$]. Therefore, if we rearrange equation (6.33) and include four additive seasonal dummies since there is no constant term, we can obtain the final form of the estimable equation as (6.34) :

$$(6.34) \quad Y_t(1+0.5\phi Y_t) = R_1 \frac{p_{t+1}}{p_t} Y_{t+1}(1+0.5\phi Y_{t+1}) + \frac{1}{\phi}\frac{z_t}{p_t} + \frac{1}{\phi}(R_1 \frac{p_{t+1}}{p_t} - 1) + \sum_{i=1}^{4} d^I_i D_{it}$$
$$+ [\frac{1}{\phi p_t} \sum_{k=1}^{\infty} (x^t_{t+k} - x^{t+1}_{t+k}) R_1^k + 0.5 Y_t^2 \{1 + \phi - \phi R_1 \frac{p_{t+1}}{p_t} (\frac{Y_{t+1}}{Y_t})^2\}$$
$$+ (\upsilon_t - R_1 \frac{p_{t+1}}{p_t} \upsilon_{t+1})]$$

where $Y_t = \frac{I_t^p}{K_t}$, $R_1 = \frac{1}{(1+\omega+\delta)}$, $p_t = (1-\tau_4)\pi_t^k$, $z_t = (1-\tau_2)(\frac{\partial Q_t}{\partial K_t})$.

Now the dependent variable, $\frac{IP_t}{K_t} = Y_t(1+0.5\phi Y_t)$, is private investment volume which includes installation costs divided by capital stock. Although ϕ is unknown, the installation costs-inclusive investment volume is observed. The first term on the right-hand side of (6.34) includes the future endogenous variable through which the expected future stream of after-tax rental (i.e. profitability) exerts an influence on current investment. The second term shows the current after-tax rental which is positively related to the current investment. The third term can be interpreted as the possible capital gains. The fourth term is four seasonal dummies, and the fifth term is the discounted value of the revisions in expectations on x_{t+k} from time t to t+1, which is unobservable. The sixth term is the unobservable measurement error of the dependent variable. Finally, and importantly, the seventh term shows that it is correlated with Y_{t+1} term and causes the errors in variables bias. The last three unobservable terms in the square brackets constitute a composite error term. Since the estimable investment equation (6.34) is derived from the equation (6.29) which implies that all the relevant information is contained in Tobin's q, it also contains all the relevant information about investment accordingly.

6.4.2 Estimation

A convenient way of estimating a rational expectations model with future expectations is the errors-in-variables method (EVM), firstly suggested by McCallum (1976a,b) and discussed in Wickens (1982) for the case of future expectations. However, since the revisions in expectations term is not observable and is added to the error terms, we cannot, in general, rule out the possibility of serial correlation in the resulting composite error term. There are two options in such circumstances. One option is to use a Non-Linear Two-Stage Least Squares (NL2SLS) estimator without attempting to adjust the coefficient estimates to reflect serial correlation, since the standard instrumental-variable procedure which corrects for serial correlation gives inconsistent

parameter estimates [e.g. Flood and Garber (1980), Hansen (1982), Hansen and Sargent (1982)]. If serial-correlation is detected, the estimated standard errors can be corrected by the procedure suggested by Hansen and Hodrick (1980) and Hansen (1982). The second option is to find an estimator that corrects for serial correlation and is consistent. The consistent estimators suggested in the literature are a forward filtering of the observations followed by an instrumental variable (IV) regression [Hayashi and Sims (1983)], Hansen(1982)'s generalized method of moments estimator, and a two-step two-stage least squares (2S2SLS) estimator [Cumby et al. (1983)].

Considering the computational costs of the second option, the NL2SLS is used to estimate the investment equation (6.34). As will be shown later, the residuals from the NL2SLS estimation do not present any significant serial correlation.The procedure of the estimation is, in principle, the same as that of EVM. That is, all the future expected variables are replaced by their realizations and the resulting equation is estimated by iterative NL2SLS. In doing this, indiscriminate use of lagged endogenous variables as instruments may lead to inconsistent parameter estimates since we cannot rule out the possible serial correlation of the composite error terms. The set of instruments used are $(\frac{Z}{p})_{t-i}$, p_{t-i}, for i = 1,2,3,4, a constant, time trend, and three seasonal dummies (D1,D2,D3).

The data for the marginal product of capital ($\partial Q/\partial K$) were obtained from the estimated production system in the previous section, by $(\partial Q/\partial K) = (1 - \hat{S}_L - \hat{S}_N)\ (Q/K)$. Since the data for investment tax credit (τ_4) were unavailable, the tax-unadjusted price of uninstalled capital π_t^k was used in the estimation (i.e. $p_t = \pi_t^k$) instead of tax-adjusted price ($p_t = (1-\tau_4)\pi_t^k$). The results are reported in Table 6.4.

The NL2SLS estimates ($\mathbf{b}_2$) are obtained by minimizing the objective function

$S(\mathbf{b}_2) = (\frac{1}{T})g(\mathbf{b}_2)'P_Z g(\mathbf{b}_2)$, where T is the number of observations, $g(\mathbf{b}_2)$ is the vector of residuals and P_Z is a projection matrix of the instruments [see Gallant and Jorgenson (1979)]. The test (QLR) statistic for NL2SLS is given by $T[S(\mathbf{b}_2)_0 - S(\mathbf{b}_2)_1]/s^2$ where $S(\mathbf{b}_2)_0$ is the minimized objective function for the null hypothesis, $S(\mathbf{b}_2)_1$ for the alternative hypothesis and s^2 is a consistent estimate of the variance of the disturbance.

Table 6.4

NL2SLS Estimates of Private Investment in Korea,

1972.II ~ 1987.III [a]

Parameter	Investment Eq.(6.34)	
R_1	0.9145 (11.112)	
ϕ	31.933 (2.315)	
d_1^I	- 0.0081 (- 1.293)	
d_2^I	0.0076 (1.335)	
d_3^I	- 0.0006 (- 0.103)	
d_4^I	0.0125 (2.601)	
R^2	0.8553	
S. E. of Regression	0.0034	
Standard Deviation	0.0085	
QLR Test for Serial Correlation :	Test Statistic	Critical Value
one period lagged residual	0.68	$\chi^2_{0.01}(1) = 6.63$
four period lagged residual	0.89	$\chi^2_{0.01}(1) = 6.63$

Notes : a Convergence achieved after 8 iterations, and the number of observations is 62. The asymptotic t-statistics are in parentheses.

This test statistic is distributed asymptotically as a chi-square with degrees of freedom equal to the number of restrictions imposed.

As can be seen from Table 6.4, there is no evidence of residual serial correlation according to the QLR test for serial correlation. Therefore, the NL2SLS estimated parameters and standard errors are consistent estimates. Furthermore, the estimated parameters are consistent with prior views regarding their signs and magnitudes. Since p_t is the price of uninstalled capital goods, the rise in p_{t+1}/p_t (i.e. if the firm expects the purchasing price of capital goods will be higher in the future) induces an increase in the current purchase of uninstalled capital goods. The current after-tax rental (z_t) exerts a positive effect on the current investment, as predicted. Since the future stream of the

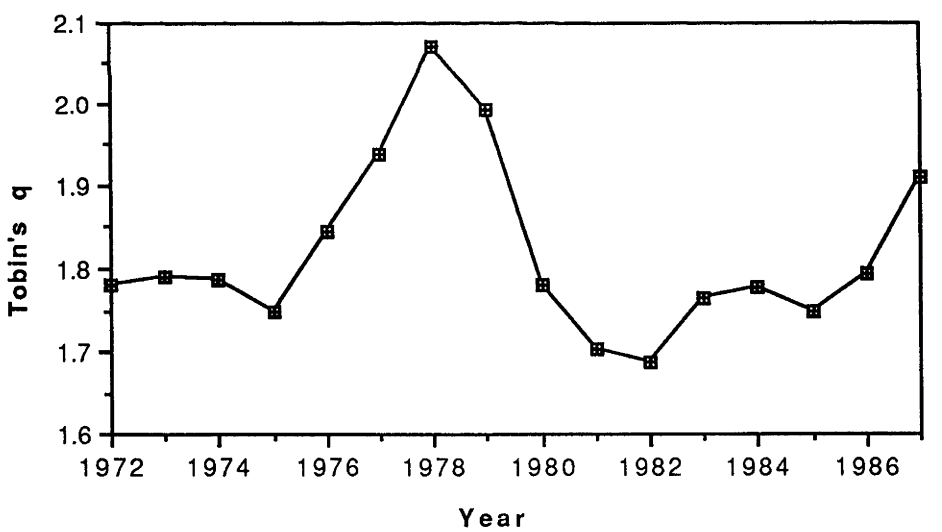
after-tax rentals is captured by the first term, optimistic expectations about the future rentals exert a positive effect on the current investment. Overall, the forward-looking investment equation (in line with the Tobin's q theory) explains reasonably well investment behavior in Korea.

6.4.3 Expectation Formation for q

Since consistent estimates of the producer's discount factor (R_1) and the parameter for adjustment cost (ϕ) have been obtained, we can easily obtain the estimated series for Tobin's q as $q_t = \sqrt{1+2\phi Y_t(1+0.5\phi Y_t)}$.[15] The estimates of the Tobin's q are reported in Figure 6.1. Throughout the sample period, the incentive for private investment has never been unfavorable. As expected, the investment incentive was less favorable after the two oil shocks than in other periods.

Figure 6.1

Estimates of Tobin's q in Korea (quarterly average, 1972 ~ 1987)



Using the estimated series for Tobin's q, we have attempted to identify the expectation formation mechanism of the Tobin's q. Assuming a linear relationship, the Tobin's q was regressed on the exogenous and predetermined variables using OLS.

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15 The estimated Tobin's q can be obtained from equation (6.29) and the relationship $\frac{IP}{K} = Y(1+0.5\phi Y)$, where $\frac{IP}{K}$ is observable private investment volume including adjustment cost, divided by capital stock.

Table 6.5

OLS Estimates of Expectation Formation of Tobin's q in Korea, 1972.II ~ 1987.III [a]

Variable		Δq_t (Tobin's q)
Constant		1.6476 (6.930)
q_{t-1}		- 0.9965 (- 8.665)
$\Delta[(1+\tau_5)\pi^n]_t$		- 0.2938 (- 2.663)
$[(1+\tau_5)\pi^n]_{t-1}$		- 0.1419 (- 2.569)
Δw_t		0.0001 (1.321)
w_{t-1}		0.0001 (2.188)
ΔK_t		6.0091 (4.770)
K_{t-1}		- 0.2863 (- 4.175)
Δr_t		- 0.1485 (- 1.357)
r_{t-1}		- 0.3035 (- 3.103)
D1		- 0.0518 (- 0.369)
D2		0.2070 (2.017)
D3		0.1451 (1.635)
R^2		0.9578
F(12,49)		92.704
Log-Likelihood Function		117.612
LR Test for Serial Correlation :	Test Statistic	Critical Value
one period lagged residual	0.75	$\chi^2_{0.01}(1) = 6.63$
four period lagged residual	4.25	$\chi^2_{0.01}(1) = 6.63$

Notes : a The number of observations is 62, and t-statistics are in parentheses.

Since the first-order dynamic specification was found to perform better than the fourth-order one, it was estimated in an extended error correction form which places no restriction on the long-run multiplier. The results are reported in Table 6.5, where the

term Δ denotes the first difference of the relevant variable. The likelihood-ratio (LR) test statistics show that there is no significant serial correlation.

As expected, the domestic relative price of the intermediate input (tariff-inclusive) and the world real interest rate exert significant negative effect on Tobin's q in both the short-run and long-run. Therefore, increases in the price of imported intermediate input and the world interest rate exert a negative effect on private investment. The capital stock exerts a positive effect in the short-run but a negative effect in the long-run.

6.5 Consumption and Expectations

6.5.1 Derivation of Estimable Equation

The estimable equation for private consumption can be obtained in a similar manner to that of private investment. The first order condition and the dynamic Euler equation in Section 6.2.1 has shown that the consumer, like the producer, takes account of the future in deciding current consumption. We need, again, a specific functional form of the utility function for the empirical estimation of consumption function. The Bernoulli utility functional form $U(C_t) = ln\ C_t$ which is widely used in the empirical literature is assumed.

From the consumer's first order conditions (6.4) ~ (6.5) and the assumed Bernoulli utility function, we can show the relationship between two consecutive periods' consumptions as equation (6.35) :

$$(6.35)\quad E_t\,(1+\tau_1)_{t+1}\pi^{c}_{t+1}C_{t+1} = e^{-(\rho-r)}(1+\tau_1)_t\pi^c_tC_t$$

$$\approx \frac{1}{1+\rho-r}(1+\tau_1)_t\pi^c_tC_t\,.$$

The approximation in the second line of equation (6.35) is the discrete time version which is more convenient for empirical analysis.

Since we relaxed the assumption of perfect foresight so that future labor income is stochastic, it is again impossible to obtain a closed-form solution for consumption, in

general. One way to overcome this problem is to allow the consumer's time preference rate (ρ) to differ from the risk-free real rate of interest (r), as in Hayashi (1982b). An additional condition is obtained from the consumer's intertemporal budget constraint. By integrating the budget constraint given in (6.2) and using the transversality condition, $\lim_{s\to\infty} e^{-(r-\mu)(s-t)}A_s = 0$, we can show that the discounted life-time consumption is equal to the sum of real non-human wealth (A) and real human wealth (H) which is the discounted life-time after tax labor income as in equation (6.36) :

$$(6.36)\quad A_t = -E_t\int_t^{\infty}[(1-\tau_3)w_sL_s - (1+\tau_1)\pi_s^cC_s]e^{-(r-\mu)(s-t)}ds$$

$$\simeq \sum_{i=0}^{\infty}[(1+\tau_1)\pi_s^cC_s - (1-\tau_3)w_sL_s]_{t+i}^{t}\left(\frac{1}{1+r-\mu}\right)^i$$

$$= \sum_{i=0}^{\infty}[(1+\tau_1)\pi^cC]_{t+i}^{t}\left(\frac{1}{1+r-\mu}\right)^i - \sum_{i=0}^{\infty}[(1-\tau_3)wL]_{t+i}^{t}\left(\frac{1}{1+r-\mu}\right)^i$$

where the first term in the third line of (6.36) is discounted life-time consumption and the second term is real human wealth which is discounted life-time (after tax) labor income. Again E_t (or superscript t) denotes expectations on the future variables as of time t. By combining equations (6.35) and (6.36), the consumer's optimal consumption rule can be shown as equation (6.37) :

$$(6.37)\quad C_t = \left[1 - \left(\frac{1}{1+r-\mu}\right)\left(\frac{1}{1+\rho-r}\right)\right]\frac{1}{(1+\tau_1)_t\pi_t^c}\left[A_t + \sum_{i=0}^{\infty}[(1-\tau_3)wL]_{t+i}^{t}\left(\frac{1}{1+r-\mu}\right)^i\right] + \nu_t$$

$$= (1-R_2R_3)\frac{1}{\Pi_t}\left[A_t + \sum_{i=0}^{\infty} W_{t+i}^{t} R_2^i\right] + \nu_t$$

$$= (1-R_2R_3)\frac{1}{\Pi_t}[A_t + H_t] + \nu_t$$

where $R_2 = \frac{1}{1+r-\mu}$, $R_3 = \frac{1}{1+\rho-r}$, $\Pi = (1+\tau_1)\pi^c$, $W = (1-\tau_3)wL$, and ν_t is a white noise error term. Note that the derived consumption function is another form of the life

cycle-permanent income model of consumption since it is derived from the optimization rule with an infinite horizon problem. The only difference from the existing permanent income models is that the above system includes the structural relationship between the consumer and the government.

By the same procedure with which we derived the investment function in the previous section, we assume rational expectations for future after-tax labor income W^t_{t+i}. Then we can obtain equation (6.38), where v_{t+k} is the error in the expectation of W_{t+k}.

$$(6.38)\quad W_{t+k} = W^t_{t+k} + v_{t+k} = E(W_{t+k} \mid \Omega_t) + v_{t+k}\ , \quad k = 1,2,\ldots\ .$$

Note that the expectation errors conditional on the information set available at time t (Ω_t) have zero mean [i.e. $E(v_{t+k} \mid \Omega_t) = 0$]. Applying the standard Koyck transformation to the geometric lead equation by subtracting $R_2 \frac{\Pi_{t+1}}{\Pi_t} C_{t+1}$ from both sides of equation (6.37), we can obtain the following result (6.39) :

$$(6.39)\quad C_t = R_2 \frac{\Pi_{t+1}}{\Pi_t} C_{t+1} + (1-R_2R_3) \frac{1}{\Pi_t} (A_t - R_2A_{t+1} + W_t)$$
$$+ [(1-R_2R_3) \frac{1}{\Pi_t} \sum_{k=1}^{\infty} (W^t_{t+k} - W^{t+1}_{t+k}) R_2^k + (v_t - R_2 \frac{\Pi_{t+1}}{\Pi_t} v_{t+1})]$$

Note that the derived consumption function (6.39) involves non-linear parameter restrictions. The expectation about the future labor income is again reflected through the future endogenous variable (the first term) as in the case of investment. The second term denotes an expected change in wealth. The third term on the right hand side of (6.39) is again the discounted value of the revisions in expectations of the after-tax labor income W_{t+k} from time t to t+1. Since this term is not observable and hence is treated as an error term, the resulting composite error composed of the last two terms in the square brackets shows a similar structure to that of investment function. Therefore, the same technical issues and estimation methods apply to the consumption function. Since we have already discussed the related technical issues, we will not repeat those issues again. The

economic implication of consumption function (6.39) is that the consumer decides the consumption according to the lifetime resources rather than to the current income, and makes the decision on the basis of some set of expectations about future labor income.

6.5.2 Estimation

Another important factor to note before estimation is that there are substantial seasonal fluctuations in aggregate consumption behavior. It is typical that different commodity bundles are being purchased in different quarters of the year. Therefore, it is highly probable that the marginal propensity to consume out of total wealth ($1-R_2R_3$) can be different in different quarters of the year.

Considering the behavioral hypothesis of a different marginal propensity to consume out of total wealth in each quarter of the year, the combined additive and multiplicative seasonal dummies are included in the consumption function as in equation (6.40) :

$$
\begin{aligned}
(6.40)\quad C_t = {} & R_2\frac{\Pi_{t+1}}{\Pi_t}C_{t+1} + (1-R_2R_3)\frac{1}{\Pi_t}(A_t - R_2A_{t+1} + W_t) \\
& + \sum_{i=1}^{3}\alpha_i D_{it}\frac{1}{\Pi_t}(A_t - R_2A_{t+1} + W_t) + \sum_{i=1}^{4} d_i^C D_{it} \\
& + [(1-R_2R_3)\frac{1}{\Pi_t}\sum_{k=1}^{\infty}(W_{t+k}^{t} - W_{t+k}^{t+1})R_2^k + (v_t - R_2\frac{\Pi_{t+1}}{\Pi_t}v_{t+1})] .
\end{aligned}
$$

The technical issues are similar to those we encountered in the previous section. Since we have future expectations variables on the right hand side of the equation, we proceed with the estimation using the errors-in-variables method (EVM). Therefore, the consumption function (6.40) is estimated by NL2SLS. The instruments used for the estimation are $(\frac{W}{\Pi})_{t-i}$, $(1+\tau_1)_{t-i}$, $(\frac{A}{\Pi})_{t-i}$, $[(1+\tau_5)\pi^n]_{t-i}$, π^c_{t-i}, for i=1,2,3,4,5, a constant, time trend, and three seasonal dummies (D1,D2,D3).

Table 6.6

NL2SLS Estimates of Private Consumption Function in Korea, 1972.II ~ 1987.III [a]

Parameter	C^b	C^c
R_2	0.9018 (19.138)	0.9408 (59.573)
R_3	0.9411 (19.248)	0.8937 (88.832)
α_1	- 0.1197 (- 2.164)	- 0.1217 (- 6.283)
α_2	- 0.1045 (- 2.340)	- 0.1264 (- 6.009)
α_3	- 0.1489 (- 3.159)	- 0.1866 (- 6.382)
d_1^C	0.0060 (0.998)	
d_2^C	0.0041 (0.808)	
d_3^C	0.0040 (0.703)	
d_4^C	0.0044 (0.862)	
R^2	0.9776	0.9770
S.E. of Regression	0.0043	0.0043
Standard Deviation	0.0266	0.0266
QLR Test for Ser. Corr.	Test Stat. [Critical Value]	Test Stat. [Critical Value]
one period lagged residual	8.02 $[\chi^2_{0.01}(1) = 6.63]$	8.05 $[\chi^2_{0.01}(1) = 6.63]$
four period lagged residual	26.98 $[\chi^2_{0.01}(1) = 6.63]$	19.51 $[\chi^2_{0.01}(1) = 6.63]$

Notes : a. The number of observations is 62 and the asymptotic t-statistics are in parentheses.
b. Consumption function with additive seasonal dummies. Convergence achieved after 3 iterations.
c. Consumption function without additive seasonal dummies. Convergence achieved after 3 iterations.

The results are reported in Table 6.6. The second and third columns are the results of the estimation of consumption function (6.40) with and without additive seasonal dummies, respectively. The QLR test for serial correlation shows that there is evidence of significant serial correlation in both cases. Therefore, the parameter estimates in Table 6.6 are, in general, inconsistent, since the consumption function (6.40) contains future expectations as explanatory variables. The existence of serial correlation strongly

implies the possibility of dynamic misspecification of the consumption function (6.40). This is because the estimable consumption equation is derived from applying a one period forward Koyck transformation to equation (6.37) to eliminate the unobservable human wealth. The merit of a one-period forward Koyck transformation is its simplicity in the sense that all future observations of the uncertain labor income are eliminated except the current observation.

In principle, however, we can apply an n-period forward Koyck transformation unless we have any constraint in the degrees of freedom. Since the data are quarterly, it is reasonable to assume that expectations for at least four-periods ahead can exert significant effects on current decisions. From specification experiments on the length of the lead observations, the following forward dynamic structure has been chosen. That is, if we apply forward Koyck transformation by subtracting $R_2^5 \frac{\Pi_{t+5}}{\Pi_t} C_{t+5}$ from both sides of equation (6.37) instead of $R_2 \frac{\Pi_{t+1}}{\Pi_t} C_{t+1}$, we can obtain the following forward dynamic equation for consumption (6.41) :

$$
\begin{aligned}
(6.41)\quad C_t = {} & R_2^5 \frac{\Pi_{t+5}}{\Pi_t} C_{t+5} \\
& + (1-R_2R_3) \frac{1}{\Pi_t} [A_t - R_2^5 A_{t+5} + W_t + R_2 W_{t+1}^{\ t} + R_2^2 W_{t+2}^{\ t} + R_2^3 W_{t+3}^{\ t} + R_2^4 W_{t+4}^{\ t}] \\
& + [(1-R_2R_3) \frac{1}{\Pi_t} \sum_{k=5}^{\infty} (W_{t+k}^{\ t} - W_{t+k}^{\ t+5}) R_2^k + (v_t - R_2^5 \frac{\Pi_{t+5}}{\Pi_t} v_{t+5})] .
\end{aligned}
$$

It is worthwhile to note that both equation (6.39) and equation (6.41) are approximations of the same equation (6.37). However, equation (6.41) shows a more general dynamic structure than equation (6.39). Expectations about future (after tax) labor income up to four-period ahead observations, as of time t, play a significant role in the current consumption decision. Considering again the behavioral hypothesis of a different marginal propensity to consume out of total wealth in each quarter of the year, the

combined additive and multiplicative seasonal dummies are added to result in equation (6.42). The resulting equation for estimation is as follows :

$$
\begin{aligned}
(6.42)\quad C_t = {} & R_2^5 \frac{\Pi_{t+5}}{\Pi_t} C_{t+5} \\
& + (1-R_2R_3)\frac{1}{\Pi_t}[A_t - R_2^5 A_{t+5} + W_t + R_2 W_{t+1}^t + R_2^2 W_{t+2}^t + R_2^3 W_{t+3}^t + R_2^4 W_{t+4}^t] \\
& + \sum_{i=1}^{3} \alpha_i D_{it} \frac{1}{\Pi_t}[A_t - R_2^5 A_{t+5} + W_t + R_2 W_{t+1}^t + R_2^2 W_{t+2}^t + R_2^3 W_{t+3}^t + R_2^4 W_{t+4}^t] \\
& + \sum_{i=1}^{4} d_i^C D_{it} + [(1-R_2R_3)\frac{1}{\Pi_t}\sum_{k=5}^{\infty}(W_{t+k}^t - W_{t+k}^{t+5})R_2^k + (\nu_t - R_2^5 \frac{\Pi_{t+5}}{\Pi_t}\nu_{t+5})] .
\end{aligned}
$$

The NL2SLS estimates of consumption function (6.42) are reported in the second column (C^b) of Table 6.7. The same set of instruments as in (6.40) was used. The QLR test for serial correlation shows that there is no evidence of serial correlation in the estimated consumption function, and hence we do not have to worry about the technical complications which could arise in the rational expectations model with the presence of serial correlation. The test procedure is the same as that of the investment function. Dropping the four additive seasonal dummies out again causes serial correlation with the four period lagged residual as shown in the third column of Table 6.7.

The estimation results show that the forward-looking consumption behavior based on intertemporal optimization is quite well explained in the more general forward dynamic structure (the second column of Table 6.7). Based on this estimation, the behavioral hypothesis α_i (i=1,2,3) = 0 is tested. As shown in Table 6.7, the null hypothesis is rejected, indicating that the marginal propensity to consume out of wealth is different for each quarter of the year. This result shows that the treatment of seasonality is very

Table 6.7

NL2SLS Estimates of Private Consumption Function in Korea, Extended Dynamic Specification, 1972.II ~ 1986.III [a]

Parameter	C^b	C^c
R_2	0.9383 (36.439)	0.9685 (125.99)
R_3	0.9695 (50.685)	0.9632 (260.93)
α_1	- 0.0562 (- 2.773)	- 0.0422 (- 8.611)
α_2	- 0.0521 (- 2.928)	- 0.0432 (- 8.297)
α_3	- 0.0549 (- 2.853)	- 0.0536 (- 8.958)
d_1^C	0.0144 (1.517)	
d_2^C	0.0126 (1.418)	
d_3^C	0.0109 (1.326)	
d_4^C	0.0049 (0.546)	
R^2	0.9621	0.9584
S.E. of Regression	0.0049	0.0051
Standard Deviation	0.0235	0.0235
QLR Test for Ser. Corr.:	Test Stat. [Critical Value]	Test Stat. [Critical Value]
one period lagged residual	3.21 [$\chi^2_{0.01}(1)$=6.63]	5.05 [$\chi^2_{0.01}(1)$=6.63]
four period lagged residual	5.60 [$\chi^2_{0.01}(1)$=6.63]	8.82 [$\chi^2_{0.01}(1)$=6.63]
QLR Test for :		
α_i (i=1,2,3) = 0	12.15 [$\chi^2_{0.01}(3)$=11.34]	135.29 [$\chi^2_{0.01}(3)$=11.34]

Notes : a. The number of observations is 58 and the asymptotic t-statistics are in parentheses.
b. Consumption function with additive seasonal dummies. Convergence achieved after 4 iterations.
c. Consumption function without additive seasonal dummies. Convergence achieved after 3 iterations.

important since we could misspecify the model by omitting the seasonal factors which cannot be picked up simply by the additive seasonal dummies.[16] Again, the consumption function based on forward looking behavior is quite well explained by the Korean data, and the result is even much better than that of the forward-looking investment. The central massage is that consumer decides the consumption out of his wealth rather than his current income.[17]

6.5.3 Expectation Formation for Human Wealth

Again we can obtain estimates of the unobservable human wealth, using the consistent parameter estimates of the consumption function. The series of human wealth can be calculated as $\hat{H}_t = \Pi_t\hat{C}_t/(1-\hat{R}_2\hat{R}_3) - A_t$, from equation (6.37). The human wealth deflated by Π_t (consumption tax-inclusive relative price of consumptin goods) was then regressed on the exogenous and predetermined variables using OLS. Again the first-order dynamic specification was estimated in an extended error correction form. The results are reported in Table 6.8. No significant serial correlation is detected. The domestic relative price of the intermediate input (tariff-inclusive) and of consumption goods exert negative effects on the human wealth in both the short-run and long-run. The non-human real wealth (capital stock and non-human financial wealth) are also negatively related to human wealth in both the short-run and long-run. However, the domestic relative price of capital goods and government investment have a positive effect on human wealth. Therefore, any changes in these variables lead to changes in the expectation of human wealth and hence exert influences to consumption accordingly.

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16 For consumption analysis, Hall (1978), Flavin (1981), Bernanke (1985), and Mankiw et al. (1985) use seasonally adjusted data, and Hayashi (1982b) uses annual data. Miron (1986) discusses the major problems of using seasonally adjusted data and shows that using seasonally unadjusted data and allowing for seasonals in preferences and technology leads to the acceptance of the permanent income hypothesis of consumption.

17 However, the hypothesis of permanent income is not tested in this chapter since the test procedure is not so powerful. Moreover, even if the permanent income hypothesis is rejected by the data, it does not necessarily mean that the hypothesis of intertemporal optimization is rejected [see Abel (1988)].

Table 6.8

OLS Estimates of Expectation Formation of Human Wealth (after tax) in Korea, 1972.II ~ 1986.III [a]

$\Delta(\frac{H}{\Pi})_t$	Parameter	T-statistic
Constant	2.2500	(5.470)
Time	0.0226	(5.701)
$(H/\Pi)_{t-1}$	- 0.9945	(- 6.925)
$\Delta[(1+\tau_5)\pi^n]_t$	- 0.1531	(- 1.259)
$[(1+\tau_5)\pi^n]_{t-1}$	- 0.1758	(- 2.011)
$\Delta[(1+\tau_1)\pi^c]_t$	- 1.0329	(- 4.407)
$[(1+\tau_1)\pi^c]_{t-1}$	- 1.3964	(- 4.180)
$\Delta\pi_t^k$	0.4565	(2.599)
π_{t-1}^k	0.4349	(1.985)
ΔK_t	0.4481	(0.527)
K_{t-1}	- 0.2577	(- 3.366)
ΔA_t	- 0.5166	(- 2.636)
A_{t-1}	- 0.4012	(- 2.869)
ΔIG_t	1.7374	(0.638)
IG_{t-1}	10.901	(2.686)
D1	- 0.1494	(- 4.231)
D2	- 0.0773	(- 2.384)
D3	- 0.0666	(- 3.919)
R^2		0.9021
F(17,40)		21.680
Log-Likelihood Function		129.745
LR Test for Serial Correlation :	Test Statistic	Critical Value
one period lagged residual	0.21	$\chi^2_{0.01}(1) = 6.63$
four period lagged residual	0.10	$\chi^2_{0.01}(1) = 6.63$

Notes : a The number of observations is 58, and t-statistics are in parentheses.

6.6 Government Decisions

The government decisions on its eight policy instruments can be derived from the first order conditions of the government [(6.17)' ~ (6.19)'] if an explicit functional form for the government objective function is given. In that case, the solution for the government decisions can be expressed in the following form (6.43) :

$$(6.43)\quad \mathbf{u}_g(t) = \mathbf{f}(\mathbf{u}_p(t),\mathbf{u}_c(t)\ ;\ \mathbf{x}_t,\ \Xi_t)$$

where $\mathbf{u}_g$ is the vector of government policies, $\mathbf{u}_p$ and $\mathbf{u}_c$ are the vectors of the producer's and consumer's decisions, $\mathbf{x}$ is the vector of exogenous and predetermined variables, and Ξ is the vector of stochastic errors. Therefore, the government decisions $\mathbf{u}_g$ [equation (6.43)] could be estimated simultaneously with the private decisions $\mathbf{u}_p$ and $\mathbf{u}_c$.

However, since the main interest of this study is in the macroeconomic adjustment process in response to the exogenous shocks $\mathbf{x}$, it is not necessary to estimate the parameters of the government objective function.[18] Instead, our goal can be achieved by estimating the reduced-form policy equations separately.

Since we assume linear reduced-form equations for the government policies, they are estimated in the extended error correction form. That is, the estimated equations are expressed in a matrix form as (6.44) :

$$(6.44)\quad \Delta_4\mathbf{u}_g(t) = V_1\Delta_4\mathbf{x}_t + V_2\mathbf{x}_{t-4} + V_3\mathbf{u}_g(t-4) + \Xi_t$$

where V_1, V_2, V_3 are the matrices of the reduced-form coefficients. The term Δ_4 denotes the difference between the current and the fourth-lagged observations (i.e. $\Delta_4 x_t = x_t - x_{t-4}$). A constant term and the time trend are included in all the seven equations (the τ_4 equation is not estimated because the data are not available).

---

18 See, for example, Friedlaender (1973) and Heller (1975) for the specification of quadratic government utility function and estimation of its parameters.

In order to test whether the unanticipated changes in the private sectors' behavior are significant, the 'surprise' terms of private decisions are included in addition to the exogenous and predetermined variables. Under the null hypothesis that the government is a Stackelberg leader, these 'surprise' terms of private decisions should not be significant. Therefore, the alternative hypothesis is that the government is a follower. The estimation involves two steps. In the first step, the private decision variables are regressed on the constant term and their own lagged variables up to the eighth-order, respectively. Then the respective estimated residual is the 'surprise' (or unanticipated change) term of the respective variable. These 'surprise' terms are included as explanatory variables in the estimation of (6.44) in the second step. The OLS estimates of the government policy decisions are reported in Table 6.9.

Interesting findings arise from the estimated government decisions.

The government consumption (in logarithms) has no significant exogenous variables. Furthermore, the 'surprises' in the private decisions are not significant from both t-test and LR-test. This result is consistent with the assumption on the government as a Stackelberg leader.

The government investment behavior [including adjustment costs IG = $I^g(1+\phi^g\frac{I^g}{K})$, in logarithms] has no significant short-run determinants but has significant long-run determinants. All the differenced terms are not significant, but the lagged level variables of π^{k*}_{t-4} and r_{t-4} show the same negative signs as the lagged level of the dependent variable, *ln* IG_{t-4}. This indicates that the long-run behavior of government investment responds negatively to the world real price of investment goods and world interest rates. The coefficient on the lagged level of the world real price of consumption goods has the opposite sign to that of the lagged level of the dependent variable. This indicates the positive long-run response of government investment to the world real price of consumption goods π^{c*}_{t-4}. This pattern of investment behavior is very similar to that of private investment, although the result is from the estimation of a linear reduced-form specification. Again, none of the private surprises was significant, indicating that the government behavior coincides with the assumption of Stackelberg leader

Table 6.9

OLS Estimates of the Reduced Form Policy Decisions in Korea, 1973.I ~ 1987.IV [a]

	$\Delta_4 ln\ G_t$	$\Delta_4 ln\ IG_t$	$\Delta_4 ln\ w_t$
Constant	- 1.403 (- 2.162)	- 1.751 (- 2.116)	0.630 (4.002)
Time	0.003 (0.435)	0.018 (0.886)	0.004 (1.122)
$u_g(t\text{-}4)^a$	- 0.316 (- 2.508)	- 0.287 (-3.211)	- 0.052 (- 2.741)
$\Delta_4\pi_t^{n*}$	0.040 (0.258)	- 0.009 (- 0.020)	- 0.301 (- 3.711)
π_{t-4}^{n*}	0.262 (1.255)	0.948 (1.454)	- 0.362 (- 3.243)
$\Delta_4\pi_t^{k*}$	0.171 (0.585)	- 0.598 (- 0.634)	0.132 (0.845)
π_{t-4}^{k*}	- 0.130 (- 0.312)	- 2.900 (- 1.957)	0.105 (0.470)
$\Delta_4\pi_t^{c*}$	0.018 (0.056)	- 0.656 (- 0.612)	- 0.034 (- 0.198)
π_{t-4}^{c*}	0.025 (0.078)	2.349 (2.086)	0.134 (0.787)
$\Delta_4 r_t$	- 0.095 (- 0.534)	- 0.652 (- 1.176)	- 0.154 (- 1.637)
r_{t-4}	- 0.249 (- 1.171)	- 1.987 (- 3.013)	- 0.195 (- 1.745)
$\Delta_4 K_{t-1}$	0.326 (0.585)	- 1.406 (- 0.805)	- 0.455 (- 1.529)
K_{t-5}	0.014 (0.094)	- 0.062 (- 0.141)	- 0.053 (- 0.671)
$ln\tilde{N}$	0.188 (1.672)	- 0.189 (- 0.550)	- 0.110 (- 1.853)
$ln\tilde{L}$	0.580 (1.208)	- 0.817 (- 0.561)	- 0.957 (- 3.747)
$ln\tilde{C}$	- 0.143 (- 0.484)	- 1.124 (- 1.151)	0.030 (0.186)
$ln\tilde{IP}$	- 0.016 (- 0.144)	0.032 (0.097)	0.108 (1.851)
$\bar{R}^2$	0.204	0.422	0.613
D. W.	1.681	1.805	1.289
F(16, 43)	1.948	3.688	6.834
LR Test [b]	4.811	2.726	18.891

Note : a The number of observations is 60, and t-statistics are in parentheses. $u_g(t\text{-}4)$ is the respective fourth lagged level of dependent variable.

b The null hypothesis is that all the (four) parameters for the private surprise terms are zero. The critical value is $\chi^2_{0.01}(4) = 13.28$

Table 6.9

OLS Estimates of the Reduced Form Policy Decisions in Korea, 1973.I ~ 1987.IV [a] (continued)

	$\Delta_4\tau_{1,t}$	$\Delta_4\tau_{2,t}$	$\Delta_4\tau_{3,t}$	$\Delta_4\tau_{5,t}$
Constant	0.102 (2.810)	0.005 (0.134)	0.106 (2.540)	0.142 (5.824)
Time	0.005 (4.307)	0.001 (0.771)	0.001 (1.093)	0.002 (3.482)
$u_g(t-4)^a$	- 0.792 (- 6.802)	- 0.201 (- 2.554)	- 0.554 (- 4.984)	- 1.371 (- 9.614)
$\Delta_4\pi_t^{n*}$	0.011 (0.445)	0.082 (3.412)	0.062 (2.380)	- 0.072 (- 5.012)
π_{t-4}^{n*}	- 0.020 (- 0.594)	0.076 (2.338)	0.080 (2.225)	- 0.105 (- 4.887)
$\Delta_4\pi_t^{k*}$	0.046 (0.940)	- 0.010 (- 0.210)	- 0.099 (- 1.952)	0.004 (0.147)
π_{t-4}^{k*}	- 0.009 (- 0.126)	- 0.005 (- 0.076)	-0.101 (- 1.372)	0.075 (1.894)
$\Delta_4\pi_t^{c*}$	- 0.088 (- 1.638)	- 0.135 (- 2.691)	0.011 (0.198)	- 0.001 (- 0.041)
π_{t-4}^{c*}	0.008 (0.162)	-0.064 (- 1.199)	- 0.035 (- 0.650)	- 0.032 (- 1.064)
$\Delta_4 r_t$	- 0.015 (- 0.501)	- 0.076 (- 2.779)	- 0.009 (- 0.287)	- 0.039 (- 2.322)
r_{t-4}	0.010 (0.265)	-0.077 (- 2.390)	0.049 (1.371)	- 0.035 (- 1.741)
$\Delta_4 K_{t-1}$	0.039 (0.406)	- 0.003 (- 0.040)	0.099 (1.032)	0.070 (1.200)
K_{t-5}	- 0.095 (- 3.974)	- 0.013 (- 0.556)	- 0.046 (- 1.862)	- 0.049 (- 3.499)
$ln\tilde{N}$	0.004 (0.200)	0.011 (0.632)	0.022 (1.130)	- 0.019 (- 1.835)
$ln\tilde{L}$	0.151 (1.922)	0.084 (1.146)	0.236 (2.864)	- 0.071 (- 1.569)
$ln\tilde{C}$	- 0.223 (- 4.547)	- 0.124 (- 2.652)	- 0.013 (- 0.257)	- 0.038 (- 1.275)
$ln\tilde{IP}$	0.037 (2.017)	- 0.006 (- 0.364)	0.002 (0.112)	- 0.002 (- 0.192)
$\bar{R}^2$	0.654	0.345	0.402	0.828
D. W.	2.059	1.639	2.679	1.865
F(16, 43)	7.979	2.943	3.477	18.809
LR Test [b]	28.351	12.258	11.118	9.568

Note : see the notes of the previous table.

An interesting case is the real wage policy. The only significant exogenous variable in the real wage equation is the world price of the intermediate input both in the short- and long-runs. The increase in the world real price of the intermediate input unambiguously leads to a decrease in the real wage both in the short-run and long-run. The import tariff policy shows the same pattern as the real wage policy : the tariff collection was reduced with the increase in the international price of the intermediate input. Therefore, the real wage and the tariff policies seem to have been applied to counteract partly the contradictionary impacts of the adverse external price shocks on the production side of the domestic economy.

The profit tax rate responded negatively to the increase in the world real interest rates, in both the short-run and long-run. This pattern is similar to the other policies. For example, the real wage policy which tried to cushion the impacts of the external shock. Interestingly, however, both the profit tax rate and income tax rate responded positively to the increase in the world real price of intermediate input price in both the short- and long-runs. This behavior can be explained by the fact that, facing the external input price shock, the government tried to dampen domestic expenditure through the two direct tax policy instruments. Regarding the information structure, the null hypothesis that government is a Stackelberg leader is rejected in the consumption tax rate equation and the real wage equation, but not in the other five equations (see the LR test statistics in Table 6.7).

6.7 Conclusions

The empirical application of the intertemporal analysis has limitations, and hence the numerical analysis has mainly been used in the literature for the analysis of the macroeconomic adjustment process of an open economy. However, the numerical analysis is analytical rather than empirical in the sense that the major parameters used are not obtained from econometric estimation using real data.

In this chapter, econometric estimation of an intertemporal optimization problem has been tried. Assuming an open-loop Stackelberg game with a decision making

sequence of government→producer→consumer, the respective reaction (decision) functions of the three agents have been derived and estimated using Korean quarterly data. As shown in the previous sections, the Korean experience is explained reasonably well by a forward-looking behavioral function derived from the intertemporal optimization rule. The major parameters of the production, input demands, investment and consumption are estimated. All of them are proved to be consistent estimates by several testing procedures. The expectation formation mechanisms of the economic agents on the main economic variables have been identified using consistent parameter estimates. Overall, the estimation results are quite satisfactory, given the fact that there are few previous empirical studies which have been able to estimate key parameters derived from optimization rules. Therefore, it is impossible to compare our results with other's, since no systematic estimation result of the Korean economy based on forward-looking behavior has been reported in the literature.

The main empirical findings are as follows. Firstly, labor, capital and imported intermediate input are found to be pairwise substitutes. The degrees of substitutability are relatively low, and especially the imported intermediate input was found to be a weak substitute to both labor and capital. This reflects a relatively rigid production technology in the use of imported intermediate input in Korea.

Secondly, the investment in Korea is explained reasonably well by the forward-looking behavior along the Tobin's q theory. Judging from the estimated series of q, the incentive for private investment was never unfavorable throughout the sample period. The increases in the domestic relative price of the intermediate input and in the world real interest rate were found to be the main negative factors to the incentive for private investment.

Thirdly, the consumption is also explained quite well by the forward-looking behavior in the sense that it is not determined by the current income but by the wealth along the permanent income hypothesis. It is shown that the treatment of seasonality is important in explaining consumption behavior. The increases in the domestic relative prices of imported intermediate input and of consumption goods are found to be negative factors to private consumption through the effects of expectations on human wealth.

However, the domestic relative price of capital goods and government investment are found to have a positive effect on private consumption.

Finally, the estimation results of the government behavior, in reduced form, also show several interesting features. The government investment responded negatively to the world real price of investment goods and world interest rates. This shows that government also behaves like a profit maximizer. Real wage policy and tariff policy responded negatively to an increase in the world real price of the intermediate input both in the short run and long run. These two policies seem to have been applied to counteract partly the contractionary impacts of the adverse external price shocks on the production side of the economy. However, both the profit tax rate and income tax rate responded positively to the increase in the world real price of intermediate input in both the short- and long-runs. The response of income tax can be explained by the fact that government tried to dampen domestic expenditure facing the adverse external shock. The hypothesis that government is a Stackelberg leader is accepted except for the consumption tax and the real wage policies.

DATA

The data used in this chapter were provided by Korea Development Institute.

P GDP deflator with 1980 = 1.0.

P^c Price deflator for private consumption, obtained from the current price private consumption divided by the 1980 constant price private consumption (1980 = 1.0).

P^k Price deflator for private fixed investment, obtained from the current price private fixed investment divided by the 1980 constant price private fixed investment (1980 = 1.0).

P^n Price index for the imported intermediate inputs in domestic currency terms (1980 = 1.0)

π^c Domestic relative price of private consumption goods in terms of the price of domestic goods (P^c/P). International price (π^{c*}) is calculated by the law of one price.

π^k Domestic relative price of capital goods in terms of the price of domestic goods (P^k/P). International price (π^{k*}) is calculated by the law of one price.

π^n Domestic relative price of imported intermediate inputs in terms of the price of domestic goods (P^n/P). International price (π^{n*}) is calculated by the law of one price.

G Real per capita government consumption in 1980 million won.

$(1+\tau_1)\pi^c C$ Real per capita private consumption which includes the indirect consumption tax, in 1980 million won. The data for private consumption in the National Accounts are the consumption tax-inclusive data. The value-added tax in Korea is consumption tax and most of the indirect taxes are consumption-type tax which are not applied to the transactions of investment goods.

$\pi^k IP = \pi^k I^p(1+0.5\phi\frac{I^p}{K})$ Real per capita private fixed investment which includes installation costs, in 1980 million won. The data for real private fixed investment in the National Accounts are installation costs-inclusive data, if any, and the installation costs-inclusive investment are observable, although the composition

of the two parts (and hence ϕ) is not known.

$\pi^k IG = \pi^k I^g(1+0.5\phi^g \frac{I^g}{K})$ Real per capita government fixed investment which includes installation costs, in 1980 million won. The data for real government fixed investment in the National Accounts are installation costs-inclusive data, if any, and theinstallation costs-inclusive investment are observable, although the composition of the two parts (and hence ϕ^g) is not known.

$\pi^n N$ Real per capita imports of intermediate inputs in 1980 million won. The nominal dollar value of the imported input imports was converted into nominal value of domestic currency terms. Real value was obtained by deflating the nominal series (in domestic currency terms) by the domestic currency import price index of the intermediate imports. Finally, the real value was divided by total population to get per capita value. The intermediate imports include (1) crude materials, (2) mineral fuels, lubricants, and related materials, (3) animal and vegetable oils and fats, (4)chemicals, (5) manufactured goods classified by materials, (6) other miscellaneous and not elsewhere classified items.

F Real per capita GDP in 1980 million won.

Q Real per capita gross output in 1980 million won, calculated by $F + (1+\tau_5)\pi^n N$.

K Real per capita total capital stock in 1980 million won.

L Per capita labor supply in man-days. Total labor supply is calculated from the total labor employment multiplied by the man-days of regular employee in mining and manufacturing industries. The resulting total labor supply is again divided by total population to get the per capita labor supply in man-days.

w Real wage rate in 1980 won per man-day. Real wage rate is obtained from per capita real wage bill (labor compensation in the National Accounts), divided by per capita labor supply (L).

τ_1 Consumption tax rate, obtained from total indirect tax revenue divided by the total private consumption.

τ_2 Profit tax rate, obtained from total profit tax revenue divided by the total profit. The total profit tax revenue is calculated indirectly as the difference between direct tax and income tax. The total profit is calculated by subtracting tariff-inclusive

imported intermediate input, wage bill, and indirect tax from the gross output.

τ_3 Wage income tax rate, obtained from total income tax revenue divided by total wage bill (labor compensation).

τ_4 Investment tax credit ratio, not available.

τ_5 Tariff rate, calculated from dividing total import tariff revenue by the total commodity imports.

r World real interest rate, adjusted for the depreciation rate of the exchange rate and the price inflation (3-month LIBOR plus the depreciation rate of won minus the rate of change of GDP deflator).

E Nominal exchange rate, period average won/$.

EI Exchange rate index with 1980 = 1.0.

POP Total population in 1,000 persons.

TIME Time trend (Time = 1, 2, 3, ····· etc.).

D_i Seasonal dummy for the i-th quarter.

A Real per capita net assets of individuals, in 1980 million won. Current price series are obtained from the Flow of Funds Account and deflated by GDP deflator and total population.

CHAPTER 7

EMPIRICAL BEHAVIOR OF THE KOREAN ECONOMY : Simulation Analysis

7.1 Introduction

This chapter simulates the effects of various combinations of exogenous economic shocks, using the aggregate model estimated in chapter 6. This quantitative simulation analysis allows us to investigate to what degree each exogenous shock affects the important macroeconomic aggregates such as consumption, investment and the current account. That is, it enables us to decompose any changes in macroeconomic outcome into several portions according to the causes or origins.

7.2 Simulation Model

The simulation model is composed of 8 structural equations and 18 identities. Following the empirical evidence obtained in chapter 6, government policies are treated as exogenous variables. The simulation model is summarized in Table 7.1.

The model has been simulated using historical values of all variables in order to check whether the simulated values of the endogenous variables trace the actual values accurately. Since we are interested in the two oil shock periods, the model is simulated dynamically over the periods from 1973:I to 1976:IV and from 1979:I to 1982:IV using the Gauss-Seidel solution algorithm. The measures of the goodness-of-fit of the dynamic simulation over the two oil shock periods are reported in Table 7.2. With the exception of the current account, the simulated values of the endogenous variables trace the actual values reasonably well. The poor performance of the simulated values of the current

Table 7.1

Simulation Model

1. $K=I^p(-1)+IG(-1)+0.98363*K(-1)$ [a]
2. LLK=LOG(K)
3. LLL=LOG(L)
4. LLN=LOG(N)
5. LLLK=LLL-LLK
6. LLNK=LLN-LLK
7. LLLKLK=LLLK*LLLK
8. LLNKNK=LLNK*LLNK
9. LLLNK=LLLK*LLNK
10. $PN=\pi^n(1+\tau_5)$
11. $PCT=\pi^c(1+\tau_1)$
12. $L=WLQ*(Q/w)*10^6$
13. N=PNQ*(Q/PN)
14. Q=EXP(LLQ)
15. F=Q-PN*N
16. wL=WLQ*Q
17. PROF=F-wL
18. $IP=I^p(1+ 0.5*31.933*I^p/K)$
19. $\dot{B}=Q-PN*N-PCT*C-G-\pi^k IP-\pi^k IG$
20. LLQ=-1.6333*(1-0.27138)+0.44433*(LLLK-0.27138*LLLK(-1))
    +0.38851*(LLNK-0.27138*LLNK(-1))
    +0.5*[-0.054576*(LLLKLK- 0.27138*LLLKLK(-1))]
    +0.5*[0.069452*(LLNKNK-0.27138*LLNKNK(-1))]
    -0.021946*(LLLNK-0.27138*LLLNK(-1))+0.27138*LLQ(-1)
    +(LLK-0.27138*LLK(-1))-0.53269*Q1-0.32644*Q2-0.31458*Q3
21. WLQ=0.44433*(1-0.95576)-0.054576*(LLLK-0.95576*LLLK(-1))
    -0.021946*(LLNK-0.95576*LLNK(-1))+0.95576*WLQ(-1)
    -0.021978*Q1+0.010645*Q2-0.0043185*Q3
22. PNQ=0.38851*(1-0.60788)-0.021946*(LLLK-0.60788*LLLK(-1))
    +0.069452*(LLNK-0.60788*LLNK(-1))+0.60788*PNQ(-1)
    +0.094414*Q1+0.033796*Q2+0.034523*Q3;
23. q=1.6476+0.00348*q(-1)-0.29376*(PN-PN(-1))
    -0.14191*PN(-1)+0.000062445*(w-w(-1))
    +0.00013563*w(-1)+6.0091*(K-K(-1))-0.28633*K(-1)
    -0.1485*(r-r(-1))-0.30346*r(-1)
    -0.051777*Q1+0.20703*Q2+0.14508*Q3
24. $I^p=(K/31.933)*(q-1)$
25. H/PCT=2.2500+0.00549*HT(-1)-0.15313*(PN-PN(-1))-0.17584*PN(-1)
    -1.0329*(PCT-PCT(-1))-1.3964*PCT(-1)+0.45646*$(\pi^k-\pi^k(-1))$
    +0.43493*$\pi^k(-1)$+0.44809*(K-K(-1))-0.25769*K(-1)
    -0.51659*(A-A(-1))-0.40115*A(-1)
    +1.7374*(IG-IG(-1))+10.901*IG(-1)
    +0.022563*TIME-0.14944*Q1-0.077264*Q2-0.066633*Q3
26. C=(1-0.9383*0.96954)*(A/PCT+H/PCT)

Note : a The quarterly depreciation rate of capital and population growth rate are given as 0.0125 and 0.00387, respectively.

Table 7.2

Results of the Dynamic Historical Simulations

	1973:I ~ 1976:IV		1979:I ~ 1982:IV	
	Mean	RMS Error [a]	Mean	RMS Error [a]
Q	0.219	0.047	0.330	0.022
F	0.182	0.042	0.261	0.015
L	25.38	3.566	26.99	1.873
N	0.033	0.005	0.072	0.010
K	0.986	0.140	2.028	0.248
q	1.793	0.118	1.800	0.128
IP	0.035	0.009	0.071	0.019
H/PCT	1.033	0.037	1.278	0.055
C	0.118	0.004	0.149	0.006
$\dot{B}$	- 0.006	0.037	- 0.013	0.017
wL	0.060	0.011	0.102	0.007
F-wL	0.122	0.030	0.159	0.009

Notes : a RMS Error = $\sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t^H - Y_t^A)^2}$

where Y_t^H = historical simulation value of Y_t

Y_t^A = actual value

T = number of periods in the simulation.

account is mainly because they are calculated as income components minus expenditure components. Therefore, all the residuals of the other variables are cumulated in the simulated current account figures. The treatment of expectations is described in the addendum to this chapter on page 164a.

7.3 Counterfactual (Base) Simulations

It is very informative to see what the economy would have looked like if all or some of the exogenous variables had remained unchanged in the periods of interest. This counterfactual analysis can be done by simulating the model using counterfactual (base) values rather than historical values of the exogenous variables. We can define the counterfactual values of the exogenous variables in a number of ways. In our counterfactual simulation, the 9 exogenous variables [π^n, π^k, π^c, $(1+\tau_1)$, $(1+\tau_5)$, r, w,

G, IG] are assumed to remain at their 1972 values for the first oil shock period (1973.I ~ 1976.IV) and 1978 values for the second oil shock period (1979.I ~ 1982.IV).

Table 7.3 reports the percentage deviation of the historical solution from the counterfactual solution. The figures reported are the deviation (of the historical from counterfactual) divided by the historical solution.

A brief comparison of the two simulation results provides several interesting observations.

Firstly, the current account (positive number means a current account deterioration) would have shown smaller deficits during the both oil shock periods if the nine exogenous variables had remained unchanged at their pre-shock levels. The figures show that the current account would have turned into a surplus by 1982 under the counterfactual case. That is the actual movements of the exogenous variables exerted negative effects on the current account altogether during both simulation periods.

Secondly, imported input demand would have been much higher if all the exogenous variables had remained at their pre-shock levels during both the two oil shock periods.

Thirdly, employment would have been higher if there had been no changes in any of the exogenous variables. Reflecting the higher factor inputs, the gross output and real GDP would also have been higher under the counterfactual situation. This counterfactual analysis shows that the combined effects of the actual movements of all the exogenous variables were slightly contractionary over the simulation periods.

Fourthly, Tobin's q and investment behavior show different responses over the two periods. During the first oil shock period, Tobin's q and investment would have been much lower if all the exogenous variables had remained unchanged at their 1972 levels. This reflects the fact that various incentive measures for investment were taken by the government during this period. During the second oil shock period, on the other hand, the situation is different ; Tobin's q and investment would then have been higher under the counterfactual situation. That is, the developments of all the exogenous variables during this period were unfavorable to investment.

Table 7.3

Comparison of Historical and Counterfactual Simulations
for the Two Oil Shock Periods
(percent deviation of historical run against counterfactual run)[a]

	The First Oil Shock Period				The Second Oil Shock Period			
	73	74	75	76	79	80	81	82
Q	- 6.30	- 10.42	- 11.49	- 12.71	- 7.15	- 13.86	- 16.01	- 17.28
F	- 3.91	- 5.15	- 7.85	- 11.41	- 6.12	- 8.46	- 10.66	- 12.81
L	- 11.38	- 14.63	- 21.74	- 34.35	- 16.11	- 19.47	- 23.16	- 28.47
N	- 41.69	- 91.45	- 60.07	- 26.23	- 19.52	- 90.24	- 87.32	- 74.13
K	0.06	- 0.45	- 0.50	0.29	0.09	- 0.44	- 1.51	- 2.02
q	- 0.05	0.91	1.57	7.46	1.30	- 4.92	- 5.05	- 1.01
IP	- 0.23	2.18	4.20	21.01	3.65	- 16.47	- 18.50	- 5.30
H/PCT	1.18	- 6.95	- 6.44	- 2.83	- 2.10	- 5.44	- 7.29	- 4.10
C	1.25	- 5.91	- 6.03	- 2.47	- 1.87	- 4.97	- 7.00	- 4.17
wL	- 1.74	- 2.42	- 3.42	- 4.23	- 3.02	- 5.46	- 7.12	- 8.16
F-wL	- 5.02	- 6.55	- 10.15	- 15.22	- 8.05	- 10.32	- 12.82	- 15.66
$\dot{B}$ [b]	15.69	94.55	68.04	62.66	33.45	57.74	112.02	50.80

Notes : a. Figures are calculated as $100*(Y_t^H - Y_t^C)/Y_t^H$ where Y^H and Y^C are the historical and counterfactual solutions, respectively.
b. Positive number indicates a deterioration in the current account.

Fifthly, the private consumption and human wealth would have been higher under the counterfactual situation. This is also the case for the wage bill and total profit.

Overall, the combined effects of the actual developments in all exogenous variables are estimated to have been contractionary compared to the counterfactual situation under which all the exogenous variables remain unchanged at their pre-shock levels. The only exception is the behavior of investment, together with Tobin's q, during the first oil shock period.

7.4 Decomposition of the Effects of Various Exogenous Shocks

Since the counterfactual (base) solution is defined and obtained, we can experiment several simulations of changes in the exogenous variables and compare the results with the counterfactual solution. Starting from the counterfactual simulation, the exogenous variables are replaced by their historical values one by one until all the nine exogenous variables are replaced by the historical values. By doing this, we can isolate the pure effects of a change in each exogenous variable.

7.4.1 The Effects of an Increase in the Domestic Relative Price of Imported Intermediate Input

The most interesting case is the pure effects of an increase in the price of imported intermediate input. Table 7.4 reports the percent deviation of the simulation of the increase in imported input price from the counterfactual solution. The figures are calculated as follows : Firstly, a simulation is carried out with only the price of imported input variable replaced by its historical values but other exogenous variables kept at their pre-shock levels. Secondly, the counterfactual solution is subtracted from the resulting solution. Thirdly, the difference is divided by the historical simulation values. The figures are expressed in terms of percentage. Note that , unlike other figures, a positive number in the current account means a deterioration in the current account.

Many observations can be made from the simulation results in Table 7.4. The theoretical analysis of chapter 4 predicted that a permanent increase in the price of an imported intermediate input would result in a fall in consumption, investment, imported intermediate input use, real wage bill and capital stock. Reflecting the initial drop in consumption and investment, the current account was predicted to show an initial surplus followed by a deficit throughout the remaining adjustment period.

The simulation of the increase in the price of the imported intermediate input confirms our theoretical predictions from chapter 4. Since the two oil shocks occurred in

Table 7.4

Effects of the Increase in the Price of Imported Intermediate Input
(percent deviation from counterfactual solution) [a]

	The First Oil Shock Period				The Second Oil Shock Period			
	(73)	74	75	76	(79)	80	81	82
Q	- 3.02	- 6.37	- 5.60	- 3.07	- 1.74	- 8.29	- 9.16	- 8.61
F	- 0.45	- 0.87	- 1.86	- 2.05	- 0.60	- 2.52	- 3.53	- 3.93
L	- 0.48	- 1.12	- 2.16	- 2.46	- 0.75	3.12	- 4.22	- 4.70
N	- 40.49	- 90.26	- 55.74	- 15.33	- 15.72	- 89.63	- 84.90	- 69.33
K	- 0.11	- 0.85	- 1.49	- 1.62	- 0.04	- 0.53	- 1.39	- 1.94
q	- 2.37	- 3.88	- 1.92	- 0.15	- 0.94	- 4.48	- 3.43	- 2.39
IP	- 7.33	- 12.38	- 7.18	- 1.62	- 2.69	- 15.05	- 13.03	- 9.49
H/PCT	- 2.89	- 6.97	- 4.04	- 0.66	- 0.85	- 4.29	- 3.74	- 2.50
C	- 2.19	- 5.51	- 3.25	- 0.54	- 0.66	- 3.42	- 3.09	- 1.96
wL	- 0.51	- 1.00	- 1.76	- 1.82	- 0.57	- 2.70	- 3.58	- 3.87
F-wL	- 0.41	- 0.80	- 1.91	- 2.17	- 0.61	- 2.40	- 3.50	- 3.97
$\dot{B}$ [b]	31.42	- 55.17	- 2.91	4.42	- 4.62	- 22.10	- 20.85	- 2.11

Notes : a. Figures are calculated as $100*(Y_t^{\pi} - Y_t^{C})/Y_t^{H}$ where Y^{π} is the solution of the simulation in which imported input price variable was replaced by its historical values. Y_t^{C} and Y_t^{H} are the solutions of counterfactual and historical simulations, respectively, as in Table 7.2.
b. Positive number indicates a deterioration in the current account.

late 1973 and 1979, respectively, our main interests are confined to the periods 1974 ~ 1976 and 1980 ~ 1982. The figures in Table 7.4 show that the increase in the price of the imported input brought about a fall in the real GDP together with a drop in the demand for labor and the imported input. This shows that the imported input price increase has a contractionary effects on the economy. The drop in expenditure was dramatic. Consumption dropped sharply from 1974. The investment drop was even larger in percentage terms. Reflecting the quick drop in consumption and investment relative to the drop in the value-added output, the current account initially improved in 1974 and then started to deteriorate. This result coincides with our predictions of current account behavior in Figure 4.1. The overall story during the second oil shock period is similar.

This pattern of current account adjustment deserves one more comment. The pure effect of the increase in the domestic relative price of imported intermediate input in isolation is an initial improvement of the current account followed by a deterioration. This result differs from the Harberger-Laursen-Metzler effect which predicts a deficit, and also differs from the result of Obstfeld (1982a) which predicts an unambiguous surplus.

Then, which of the nine exogenous variables are responsible for the observed current account deficit during these periods ? Next section gives the decomposition of changes in the major macroeconomic aggregates including the current account.

7.4.2 Decomposition of the Changes in Major Macroeconomic Aggregates

As discussed earlier, the effects of each exogenous variable on the endogenous variables are isolated by successive simulations. That is, starting from the counterfactual simulation, the exogenous variables are replaced with their historical values one by one. The order of the successive simulations was π^n, $(1+\tau_5)$, r, w, $(1+\tau_1)$, G, IG, π^k and finally π^c. Therefore, the difference between the first successive simulation result with π^n replaced with its historical values and the counterfactual result provides the pure effects of the change (increase) in π^n on all the endogenous variables. This result was discussed and reported in Table 7.4. The second simulation is done by replacing π^n and $(1+\tau_5)$ with their historical values. Next, the first simulation results are subtracted from the second simulation results. Then, the differences between the second result and the first one are the pure effects of the change in $(1+\tau_5)$ on all the endogenous variables. The final simulation which replaces all the exogenous variables (from π^n to π^c)by their historical values coincides exactly with the historical simulation.[1]

Rearranging the isolated effects of each exogenous variable according to major macroeconomic aggregates, we can obtain the results of Table 7.5 ~ Table 7.10. All the figures reported in those tables are in terms of percentage deviation attributable to each exogenous shock in isolation. The percentage is calculated as the value of isolated effect divided by the historical simulation value of the variable for each period. The figures are quarterly average value during the period of analysis.

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[1] The order of successive simulation did not cause much difference in the results.

Table 7.5 reports the decomposition percentage for the changes in the current account. The main reasons behind the current account deterioration during the first oil shock period were the increases in the real wage, the government consumption and the domestic relative price of capital goods. The fall in the world real interest rate during this period also contributed to an increase in the deficit. However, the consumption tax and the government investment policy exerted a dampening effect on the increase in the current account deficit. The situation was similar during the second oil shock period except that the contribution of the government consumption to the current account deterioration was much less. Instead, the sharp increase in the world real interest rate exerted a significant current account deterioration effect during this period.

Table 7.6 reports the decompositions for real GDP. The main contractionary effects during both periods were due to the increases in the price of imported intermediate input and the real wage. The fall in the government investment also exerted a small contractionary effect. In particular, the sharp increase in the world real interest rate during the second oil shock period was an additional factor for the real GDP contraction during that period.

Table 7.7 and 7.8 report the decompositions for the consumption and investment volumes, respectively. The main contractionary factor for consumption and investment was the increase in the price of the imported input as discussed in the previous section. The percentage fall in investment was larger than that of consumption in response to the increase in the price of imported input. The investment behavior deserves more explanation because it rose sharply during the first oil shock period, but fell during the second oil shock period. The main factor behind the increase in investment during the first period was the fall in the world real interest rate. When the real interest rate rose during the second period, investment dropped dramatically. The channel through which the world real interest rate affects the investment is, of course, Tobin's q.

Finally, Table 7.9 and 7.10 show the decomposition percentage for labor employment and imported input use, respectively. Both the price of the imported input and the real wage exerted the largest negative effects in both cases. The sharp increase in the world real interest rate during the second oil shock period also exerted negative effects

on factor demand in both cases. Interestingly, tariff policy exerted positive effects on imported input demand. This is because tariff rates have been reduced throughout the period of analysis as a part of a program of trade liberalization. In all cases, the government investment policy was contractionary.

Table 7.5

Decomposition Percentage for the Current Account ($\dot{B}$) [a]

	1973 ~ 1976	1979 ~ 1982
$\dot{B}$	60.24	63.50
$d\pi^n$	- 5.56	- 12.42
$d(1+\tau_5)$	0.55	2.36
dr	2.35	12.80
dw	36.61	64.62
$d(1+\tau_1)$	- 0.92	- 2.46
dG	17.42	0.08
dIG	- 0.66	- 0.69
$d\pi^k$	15.88	17.05
$d\pi^c$	- 5.43	- 17.84

Note : a A positive number means a deterioration in the current account.

Table 7.6

Decomposition Percentage for Real GDP (F)

	1973 ~ 1976	1979 ~ 1982
F	- 7.08	- 9.51
$d\pi^n$	- 1.31	- 2.65
$d(1+\tau_5)$	0.04	0.17
dr	0.68	- 1.29
dw	- 5.90	- 5.37
$d(1+\tau_1)$	0	0
dG	0	0
dIG	- 0.60	- 0.38
$d\pi^k$	0	0
$d\pi^c$	0	0

Table 7.7

Decomposition Percentage for Consumption (C)

	1973 ~ 1976	1979 ~ 1982
C	- 3.29	- 4.50
$d\pi^n$	2.87	- 2.28
$d(1+\tau_5)$	0.17	0.25
dr	- 0.07	0.18
dw	- 0.07	- 0.26
$d(1+\tau_1)$	-0.66	- 0.71
dG	0	0
dIG	- 0.29	- 0.03
$d\pi^k$	1.63	1.39
$d\pi^c$	- 1.13	- 3.04

Table 7.8

Decomposition Percentage for Private Investment (I^p)

	1973 ~ 1976	1979 ~ 1982
I^p	6.79	- 9.16
$d\pi^n$	- 7.13	- 10.07
$d(1+\tau_5)$	0.38	1.08
dr	5.72	- 14.54
dw	8.80	14.56
$d(1+\tau_1)$	0	0
dG	0	0
dIG	- 0.99	- 0.19
$d\pi^k$	0	0
$d\pi^c$	0	0

Table 7.9

Decomposition Percentage for Labor Employment (L)

	1973 ~ 1976	1979 ~ 1982
L	- 20.53	- 21.80
$d\pi^n$	- 1.56	- 3.20
$d(1+\tau_5)$	0.05	0.24
dr	0.79	- 1.45
dw	- 19.21	- 17.01
$d(1+\tau_1)$	0	0
dG	0	0
dIG	- 0.60	- 0.38
$d\pi^k$	0	0
$d\pi^c$	0	0

Table 7.10

Decomposition Percentage for Imported Input (N)

	1973 ~ 1976	1979 ~ 1982
N	- 54.86	- 67.80
$d\pi^n$	- 50.46	- 64.90
$d(1+\tau_5)$	1.76	4.92
dr	0.66	- 1.23
dw	- 6.23	- 6.33
$d(1+\tau_1)$	0	0
dG	0	0
dIG	- 0.59	- 0.27
$d\pi^k$	0	0
$d\pi^c$	0	0

7.5 Conclusions

This chapter has simulated the effects of exogenous economic shocks on the major macroeconomic aggregates of the Korean economy. The simulation was carried out over the two oil shock periods, using the estimated model in chapter 6. In particular, it allowed us to isolate the macroeconomic effects of each individual shock.

The simulation results confirmed most of the theoretical predictions of chapter 4. and 5. Especially the imported input price increase resulted in a quick drop in private consumption and private investment. The employment, imported intermediate input use and capital stock were also found to decrease in response to the imported input price increase. Reflecting the drop in factor use of labor, capital and imported input, the real GDP also fell. Since the initial drop in expenditures exceeded the drop in the real GDP, the initial response of the current account was found to be an improvement. Thereafter, the current account started to deteriorate (Table 7.4). The decomposition for the current account shows that the observed current account deterioration over the simulation periods was mainly driven by the increases in the real wage, the price of capital goods and the government consumption (Table 7.5). Judging from the relative magnitude of the effect, the real wage played a significant role in the change of the current account. Overall, the increase in the price of imported input exerted contractionary effects on the major macroeconomic aggregates of the Korean economy.

The increase in the world real interest rate also contributed to the current account deterioration and exerted a sharp contractionary effect on private investment. The government investment policy was also contractionary throughout the simulation period. However, the tariff rate has been reduced as a part of trade liberalization, and hence counteracted the contractionary effects of the external shocks. The qualitative result is also consistent with the theoretical prediction of chapter 5 in the other way round.

Another implicit conclusion from this analysis is that the role of labor market and real wage is a very important factor in the macroeconomic adjustment process. A more explicit treatment of labor market in the analysis of macroeconomic adjustment may be a promising future research area.

CHAPTER 8

CONCLUSIONS

8.1 Restatement of the Problem and Point of Departure

This thesis has been concerned with exogenous economic shocks and macroeconomic adjustment in Korea. Exogenous economic shocks refer to any sudden changes in the international economic environment and in domestic policies. Macroeconomic adjustment to these exogenous shocks is defined as resource reallocation in a Pareto efficient manner, intersectorally as well as intertemporally.

Once an exogenous economic condition is changed for an economy, it is desirable for the economy to respond to the changed exogenous condition in an efficient way. The response usually involves an adjustment in such major macroeconomic aggregates as production, consumption, investment and, for an open economy, the current account. The central questions are 'what are the effects of', and 'how to adjust to', a sudden change in the exogenous economic environment, whether that change results from an external shock or a domestic policy change.

The actual adjustment patterns of various countries after the two oil shocks are complex and varied, as already shown in chapter 2. Some governments responded to the shocks with contractionary policy while others responded with expansionary policy. The responses of expenditure (especially its investment component) varied among countries. Some countries' responses to the shocks generated a current account surplus, while others' responses generated a current account deficit. A range of factors are responsible for the highly differentiated responses across countries : (i) it is hard for govenments and economic agents to identify whether an exogenous shock is temporary or permanent, and different entities form different views ; (ii) the effects of an exogenous shock are not confined to a specific sector or interest group within an economy, so that differences in the interests and in the character of the interaction between sectors and interest groups

introduce variety into the responses ; (iii) the particular objective functions of economic agents, especially their attitudes to risk, affect the responses ; (iv) the degree of openness and resource endowments of an economy also contribute to the complexity of the actual adjustment pattern of various countries.

At a theoretical level, the intertemporal general equilibrium framework has been heavily used to explain the macroeconomic adjustment process in an open economy. Since the framework incorporates aggregate supply as well as demand, it is a useful tool for analyzing the effects of a supply shock on macroeconomic adjustment. Depending on the factor emphasized, the theoretical predictions about the effects of and adjustment to an exogenous shock differ from model to model. Moreover, the intertemporal framework has limited empirical application despite the theoretical elaborateness. This has made it hard to find a formal framework which can be used to analyze the specific experience of the Korean economy.

This thesis has tried to overcome these apparent problems and to analyze the experience of Korean adjustment qualitatively and quantitatively in an intertemporal general equilibrium framework. The main contribution of this thesis has been the following aspects. Firstly, it has provided an alternative infinite-horizon optimizing framework incorporating saving, investment and the current account. The introduction of a risk premium on foreign borrowing, and the related negative externality allowed us to obtain a more realistic pattern of macroeconomic adjustment subject to an exogenous economic shock. Secondly, the role of government policy in the macroeconomic adjustment process has been introduced. Since the observed macroeconomic behavior is the complex outcome of multiple, rather than single, changes in the exogenous conditions, the introduction of the government role has provided one possible explanation for the adjustment pattern differing among countries. Thirdly, and importantly, the study has applied the intertemporal general equilibrium framework to empirical estimation and simulation. Given the fact that examples of empirical application of an intertemporal model are rare, our empirical application has been quite successful. Moreover, we have been able to decompose the effects of various exogenous shocks according to their causes or origins, through simulation exercises.

8.2 Main Findings

8.2.1 The Theoretical Results

As a starting point, this thesis has developed an intertemporal optimizing model of saving, investment and the current account. The main feature of this theoretical model is that it has introduced a risk premium to the real interest rate and the related externality of foreign borrowing to reflect the specific character of an open developing economy like Korea. Additionally, an imported intermediate input is introduced as a third factor of production. This feature provides more realistic theoretical results for a small open resource-poor economy like Korea.

The main theoretical results obtained are as follows. An unanticipated permanent increase in the price of the imported intermediate input results in long-run reductions in the capital stock, consumption, real wage, and intermediate input use. When the imported input price rises, consumption falls immediately, reflecting the fall in real income (value-added output) and continues to fall until it reaches a new equilibrium at a lower level. The capital stock and the use of imported input in production also fall, and hence income falls. The current account responds with a surplus immediately after the shock, but turns into deficit during the remainder of the adjustment period. The speed of adjustment and the time when the current account turns into a deficit depends on the relative size of the stable eigenvalues of the system (chapter 4). This pattern of current account adjustment shows contrasts with existing theory, which predicts an unambiguous surplus [Obstfeld (1982a)], or deficit (Harberger-Laursen-Metzler effect).

Assuming a balanced budget, the qualitative effects of changes in capital income tax and labour income tax are found to be similar. When a permanent increase in one of these taxes occurs, the capital stock and consumption decrease and the current account shows an initial surplus followed by a deficit. The impact effect on the current account is a surplus, which is the outcome of the quick drop in consumption relative to investment. For the remainder of the period of adjustment, however, the current account shows a deficit.

A permanent increase in the investment subsidy operates in the other direction. The capital stock and consumption increase, and the current account shows an initial deficit followed by a surplus. Unlike the capital income or labor income taxes, the consumption tax and import tariff do not affect the long run real wage. A balanced budget increase in the consumption tax completely crowds out the private consumption. The import tariff operates qualitatively in the same way as a capital income tax on the capital stock, imported input use and consumption (chapter 5).

Although the government's objective is not explicitly introduced, the result has shown the possibility that the pattern of macroeconomic adjustment after external economic shocks could be affected and complicated by government policies. This can provide one explanation for the empirical observation that the patterns of macroeconomic adjustment after the two oil-shocks differed from country to country.

8.2.2 Empirical Findings

The main challenge of this study has been to identify the qualitative and quantitative effects of various exogenous economic shocks on macroeconomic adjustment. Since the macroeconomic outcomes are complex results of changes in multiple exogenous economic conditions, it is highly desirable to isolate the effects of each individual exogenous shock. For this purpose, the intertemporal optimizing model developed is econometically estimated, and the resulting model is used for simulating the effects of various exogenous shocks.

In order to apply the intertemporal framework empirically, we have to clarify the information structure, since the intertemporal framework inevitably involves some empirically intractable components. Therefore a Stackelberg game between the government and private sectors is assumed, with a decision making sequence of government→producer→consumer. The resulting reaction functions of the three agents are derived and estimated assuming rational expectations about key future variables (chapter 6). The estimation results are satisfactory. In addition to the estimation of key parameters, the expectations formation mechanism of the economic agents for the main economic variables are identified. Using the estimated system, various simulations of the

effects of exogenous shocks are carried out. The empirical findings from the estimation and simulation analyses are consistent with the theoretical results obtained in the earlier chapters.

The econometric estimation (chapter 6) generate three main results. Firstly, the production technology in the use of imported intermediate input is relatively rigid in Korea. This conclusion is supported by the finding that the imported intermediate input is a weak substitute for both labor and capital. Secondly, investment in Korea is explained reasonably well by forward-looking behavior along the lines of Tobin's q theory. The expectations formation mechanism for Tobin's q shows that the increase in the price of imported intermediate input and the world real interest rate are the main negative factors to the investment incentive. Thirdly, consumption behavior is also explained quite well by the forward looking behavior. The expectations formation mechanism for human wealth shows that the increases in the prices of imported intermediate input and consumption goods are the main negative factors to private consumption.

The simulation results (chapter 7) using the estimated model confirms most of the theoretical predictions of chapter 4 and 5. In particular, the imported input price increase results in a quick drop in private consumption and private investment. The employment, imported intermediate input use and capital stock are also found to decrease in response to the imported input price increase. Reflecting the drop in the use of labor, capital and imported input, the real GDP also falls. Since the initial drop in expenditures exceeds the drop in the real GDP, the initial response of the current account is found to be an improvement. Thereafter, the current account started to deteriorate. The decomposition analysis shows that the observed current account deterioration over the simulation periods was mainly driven by the increases in the real wage, the price of capital goods and the government consumption (Table 7.5). Judging from the relative magnitude of the effect, the real wage played a significant role in the change in the current account. Overall, the increase in the price of imported input exerts contractionary effects on the major macroeconomic aggregates of the Korean economy.

The increase in the world real interest rate also contributes to the current account deterioration and exerts a sharp contractionary effect on private investment. The

government investment policy is also contractionary throughout the simulation period. However, the tariff rate has been reduced as a program of trade liberalization, and hence counteracted the contractionary effects of the external shocks. The qualitative result is also consistent with the theoretical prediction of chapter 5.

8.3 Agenda for Further Research

This thesis has provided an intertemporal general equilibrium framework to examine the relationship between exogenous economic shocks and macroeconomic adjustment in Korea. It has shown a series of theoretical framework and its application to empirical estimation and simulation analysis to examine the specific experience of Korea.

It is important that future research is directed along these lines, given the weakness of demand-oriented models in analyzing the same issues. The merit of this approach is that it provides much better understanding of the way the economy operates. Therefore, it is desirable to extend this type of approach to enhance our understanding about the macroeconomic adjustment process which is intrinsically the outcome of intertemporal choices.

However, many preconditions have to be satisfied before the approach can be applied in a completely satisfactory way. The present study does not incorporate the monetary side of the economy. More complete characterization of the labor market and real wage is desirable, since the importance of the real wage in macroeconomic adjustment is demonstrated in the simulation analysis. These two directions will provide promising opportunities for the extension of the present study.

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